IEEE Trial-Use Recommended Practice for Integrating Power Plant Computer-Aided Engineering (CAE) Applications

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Abstract: A data model, called the plant information network, that standardizes categories of generating plant data and data relationships, is presented. Guidelines are provided for using the model to integrate computer-aided engineering (CAE) applications across the spectrum of plant-work activities during the complete cycle of the plant from site selection through decommissioning. Instructions are given to aid the engineering, construction, and operating groups of the utility in specifying integrated CAE applications. The information engineering concepts that are the basis for integrated CAE development are covered.
Keywords: CAE, CAE applications, computer-aided engineering, data models, plant data, plant information networks

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Foreword

(This foreword is not a part of IEEE Std 1150-1991, IEEE Trial-Use Recommended Practice for Integrating Power Plant Computer-Aided Engineering (CAE) Applications.)

In May 1987, the Electric Power Research Institute (EPRI) published the results of a two-and-a-half-year project entitled *Guidelines for Specifying Integrated Computer Aided Engineering Applications for Electric Power Plants* (Report NP-5159-Ms, Research Project 2514-3). This project developed a set of guidelines that enabled electric utility engineers to prepare specifications for integrated computer-aided engineering (CAE) applications. This integration is based on a single data model that identifies common data requirements across the spectrum of generating plant activities from site selection through plant decommissioning.

This guideline presents a method for integrating CAE applications specifically for the electric utility industry (hereinafter referred to as the industry). It contains the data model, or Plant Information Network (PIN), and the methodology and procedures to use the PIN for developing CAE application functional specifications.

This recommended practice is based on the EPRI guideline. It advocates the use of a single data model and recommends that the EPRI model be used.

It is generally recognized that better control of data resources greatly contributes to improved efficiency. The lack of access to and control of data, not the lack of data, causes inefficiencies in resource utilization throughout the generating-plant life cycle.

CAE is a development in engineering automation in which the engineering process is modeled within the computer as a progression of interrelated work functions. A significant effort is under way within the industry to develop a wide variety of CAE systems and applications, including plant design applications, construction material and commodity control systems, and plant operations and maintenance applications. However, without a common plant data integration structure, a continuation of the problems that have plagued traditional automation efforts, namely, data redundancies and inconsistencies, duplication of data capture efforts, and information lags, can be expected.

This plant data model will serve as a mapping tool for new applications. It will position a particular application for a given plant activity into the overall picture of the plant life cycle. Integration opportunities will be identified for the developer in the data model without requiring an exhaustive understanding of the entire generating plant process.

A single data model

— Facilitates the development of additional CAE applications
— Supports the integration of existing CAE applications
— Improves the transfer and sharing of data between organizations and work activities
— Helps make information exchanges more accurate, timely, and consistent
— Furnishes a common view of the data requirements of an organization
— Improves data and software integration to reduce redundancy and thereby improves data consistency and increases efficiency

The PIN methodology and procedures have been developed and defined to provide a data model of plant-related information for the entire plant life cycle. This recommended practice is defined in such a way as to encourage utilities and suppliers to support and implement the PIN.

This recommended practice offers utilities and their suppliers a standard that can be used to model the information flow through the plant life-cycle activities. In this way, plant information integration will be brought to CAE development for the power industry so that communications are facilitated within a utility and among the utility, the A/E, and the suppliers. Standardization can lead to CAE implementation that promotes efficient resource utilization and that takes advantage of the whole knowledge base of the generating plant processes.

This IEEE working group would like to thank EPRI, Palo Alto, CA, and especially Dr. John J. Carey, the project manager, for its efforts and funding of the original development project. This project was primarily performed by Duke Power Company, Charlotte, NC.

The report described earlier is the copyrighted material of the Electric Power Research Institute, which has licensed it to the IEEE for use in the development of this recommended practice.

This recommended practice was prepared by the Working Group for Integrating Computer-Aided Applications Using a Single Data Model, Station Design Subcommittee of the Energy Development and Power Generation Committee. At the time this recommended practice was approved, the members of the working group were:

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1. Introduction

1.1 Scope

This recommended practice presents a data model that standardizes categories of generating plant data and data relationships. It provides guidelines for using this data model to integrate computer-aided engineering (CAE) applications across the spectrum of plant work activities during the complete life cycle of the plant from site selection through decommissioning. It contains a description of the plant data model and instructions for the engineering, construction, and operating groups of the utility for specifying integrated CAE applications.

The purpose of this recommended practice is

1) To introduce the information engineering concepts that are the basis for integrated CAE development
2) To present a data model that represents the data and data relationships supporting the plant work activities; this model is known as the Plant Information Network (PIN)
3) To define guidelines for applying CAE system technology to the generating-plant life cycle, based on the PIN
4) To describe methods for developing functional specifications for CAE applications based on this model

The goal of this recommended practice is to show how to use the PIN as a reference when developing a functional specification for a CAE application. It is directed to both CAE application users and developers. A common data model should be adopted, and existing procedures and organizational structures relative to the data model should be evaluated to successfully integrate CAE applications in the work environment.

1.2 Recommendation

This recommended practice

1) Advocates the use of a single data model for integrating CAE applications
2) Recommends that the EPRI PIN be used as the single data model (see [1])

2. References

[1] Electric Power Research Institute, *Guidelines for Specifying Integrated Computer-Aided Engineering Applications for Electric Power Plants* (EPRI Report NP-5159-Ms).[1]

[2] IEEE Std 610.12-1990, IEEE Standard Glossary of Software Engineering Terminology (ANSI).[2]

[3] IEEE Std 730-1989, IEEE Standard for Software Quality Assurance Plans (ANSI).

[4] IEEE Std 830-1984, IEEE Guide for Software Requirements Specifications (ANSI).

[5] Downs, H. R., *Software Development and Maintenance Guidelines, volume 3*. Palo Alto, CA: Electric Power Research Institute, 1984.

3. Definitions

activity: A set of tasks that relate to the performance of a specific function in a plant phase. Information is compiled throughout the Plant Information Network (PIN) at the activity level.

activity coordinator: A person who is an expert in the methodology and development of the activity documentation packages and who is responsible for coordination and development of the activity documentation packages with the activity technical contacts.

activity data list: A list that itemizes the major data items used by the activity, gives a brief description of each data item, and lists other activities that provide or receive each data item.

activity description: An overview of the activity that briefly describes the activity and its scope, and delineates the boundaries and major tasks of the activity.

activity documentation package: A summary of the results of the activity investigation which includes the activity description, activity process diagram, activity data list, activity entity-relationship diagram, and the activity support modules.

activity entity-relationship (E-R) diagram: A diagram that defines the data contents of the activity by identifying its data entities, associated data attributes, and the relationships among data entities.

activity list: A list containing names of activities that define the work processes of a generating plant from conception to decommissioning. There are approximately 400 such activities that comprise the power-plant life cycle and are mainline activities that are common throughout the industry. The list also separately contains brief descriptions of the activities.

activity process diagram: A diagram that shows the relationships and flow of tasks within an activity and represents the process required to complete an activity.

activity support modules: Procedures or computer programs that operate on the data associated with the activity.

activity technical contact: A person who is knowledgeable about the functions, tasks, data, and details related to an activity.

attribute: A property or fact about the entities in an entity set.

automation: Computerization of data or of a process that uses that data.

[1]EPRI documents are available from the Electric Power Research Institute, 3412 Hillview Avenue, P. O. Box 10412, Palo Alto, CA 94303, USA.
[2]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, Piscataway, NJ 08855-1331, USA.

cardinality: The numeric relationship between entity sets, labeled as one to one (1-1), many to one (M-1), or many to many (M-N), which indicates the number of items in one entity set that could possibly be associated with the items in another entity set.

computer-aided engineering (CAE): The application of computers to the engineering process. The term now commonly applies to any computer system or program that manipulates data for the purpose of assisting engineering, design, procurement, maintenance, etc.

concurrency: The process of multiple users accessing and manipulating a data item simultaneously, with the data-base management system linking the transaction of each user so that the access appears to be sequential.

customizing: Modifying, or adding to, the structure of data in the PIN to tailor the general data requirements to an needs of an organization. Customizing can result in an organization-specific data model that should be cross-referenced to the PIN.

data flowpath: A segment of the overall plant data flow that represents one attribute sent from a providing activity to a receiving activity.

data model: A conceptual representation of the information requirements, data flows, and data relationships for an organization, facility, activity, or process.

entity: A group of like items or subjects that can be individually identified and about which information is recorded. Examples include cable, drawing, modification, and system *Syn*: **entity set.**

entity-relationship (E-R) diagram: See **activity entity-relationship diagram.**

functional specification: A formal description of the essential requirements of a software product. It specifies the objectives of the software application, the functions that will meet those objectives, the information requirements, the internal data flows, and the external interfaces.

hierarchical data base: A data-base system that uses tree structures to represent the data.

integration: Providing a single set of data for use between multiple activities or departments (multiple application data base).

key (relational data base): A field or group of fields in a relational data-base table that uniquely defines each row within that table. A composite key is made up of more than one field in the table.

network data base: A data-base system that uses directed graphs to represent the data.

normalization: The decomposition of more complex data structures according to a set of rules designed to give simpler, more stable structures.

parent entity: An entity set that has other entities dependent on and related to it called subset entities. The subset entities are linked and related to other entity sets through the parent entity set.

phase: A major stage within the generating-plant life cycle. See **plant life cycle.**

plant information network (PIN): A representation of both the flow and the structure of the information that supports the discrete activities occurring during the life cycle of the plant.

plant life cycle: The life of a power plant from conception to decommissioning. In this model, the cycle consists of five phases: site selection and plant concepts, design, construction, operation, and decommissioning.

RAM: Reliability, availability, and maintainability of the plant. In economic analysis, the increase in RAM due to data integration or automation is sometimes quantified as a benefit. In computer applications, this refers to random access memory, which is not used in this text.

relational data base: A data base that represents data as a collection of tables linked through common entries.

relationship: A specific association that exists between entity sets or entities of a set that can be described by a single word or phrase.

software life cycle: The various phases for software development from initial conception to final release and maintenance.

subset entity: Entities that are related to and dependent on other primary entity sets called parent entity sets.

4. Recommended Methodology

4.1 Basic Concepts of CAE Application Integration

This section describes the basic concepts for integrating CAE applications. These include

- Information engineering
- Plant information network
- CAE application development practices
- Functional specification
- Common plant data model

These ideas and techniques combine to provide the user with a standard guideline for CAE application development, focusing on the data requirements of the functional specification, to achieve integrated CAE applications. A basic understanding of these concepts is necessary to implement these guidelines.

4.1.1 Information Engineering

Information engineering is an approach to analyzing and representing data that maximizes integration and allows the data to be used for a variety of purposes. A central idea in information engineering is the development of a generic description of the data requirements of the organization, called the data model. A data model consists of primary data items (entities), associations between these entities (relationships), and pertinent descriptive properties of the entities (attributes).

The principles of information engineering were used to generate the plant data model described in 4.2. In applying these concepts to a plant-specific application, one should adhere to the principles discussed in 4.1.1.1 through 4.1.1.5.

4.1.1.1 Focus the Data Model on Data Rather Than Procedures

By concentrating on the data involving plant activities rather than on the procedures that actually operate on that data, a more stable model can be developed. This is because the kinds of data involved in plant activities remain mostly constant with time, although the procedures (whether manually performed or computerized) operating on the data may change frequently.

4.1.1.2 Represent the Data Generically

Generalized data structures are flexible, maximizing data sharing, so that many applications may create separate logical paths to use the data. For example, a data item such as cable is preferred over power cable or instrument cable, since many activities such as routing, pulling, and termination will be common.

4.1.1.3 Reduce or Eliminate Redundant Data Storage

Typically, many different activities support separate versions of the same data. In each activity, data is organized in a distinct data-base structure, whether the data is computerized or not, and then that data is transferred (manually or by computer) to other activities. This redundancy often causes data inconsistencies among activities, errors in data transfer, time delays while the information is communicated between activities, and poor decision making due to conflicting or untimely information.

The plant data model makes it possible to consolidate data used in different plant activities in one place so that a single copy is available to all activities using that data. In this manner, the need for duplicate storage and communication of data among activities is reduced, and the information is up-to-date, manageable, and auditable. Using the plant data model permits a conscious decision about retaining redundancy.

4.1.1.4 Use the Model When Developing New Procedures

Currently, procedures are often developed independently in each functional area, and the necessary data are then communicated to other areas. Using the integrated plant data model, new procedures can be developed that may cross functional boundaries in the plant. These new procedures can recognize and anticipate other uses of the data. This type of procedure development can improve productivity if the data exists in one place and is simultaneously shared by all users. The errors and time lags involved in data transfer are eliminated.

4.1.1.5 Use the Model for Both Manual and Computerized Tasks

The plant data model should be used to design and modify either manual or computerized tasks. It should also be used to facilitate communication among diverse tasks. In addition, the plant data model is readily adaptable to any computerized or manual data management system.

4.1.2 Plant Information Network

The PIN is a concept that applies information-engineering principles to the generating-plant life cycle. It combines a common plant data model with the activities that use the data represented by the model and provides a foundation on which to build integrated CAE applications.

Applying information-engineering principles to an electric power generating plant results in the type of structure shown in Fig 1. Conceptually, the structure has four major components: activities, a common plant data base, data flowpaths, and interfaces between the activities and the data base. Together, these components depict the basic elements of the PIN, which encompasses plant-related information for the entire life of the plant. A set of discrete activities, A_N, which occur during the life of a plant, are along the time line. An activity is defined as any work function performed in support of the plant: A_1 can be site selection, A_2 can be architectural design, A_3 can be piping design, A_4 can be piping erection, A_5 can be plant chemistry control, and so forth. When combined, these activities ideally define all functions needed to support a plant from conception to decommissioning.

Although Fig 1 presents these activities as discrete and sequentially processed, many frequently overlap on the time line and are actually processed iteratively. However, for the purpose of these guidelines, this figure accurately represents the intended concepts.

Associated with each activity is a data base, DB_n, that contains all the information required to support that activity. A data base consists of computer data files, DF_n, manual filing systems, and the like, which contain various parts of the information. Also associated with each activity are support modules, M_n, which operate on the activity data to perform a specific task within the process. Examples of support modules are computer programs, procedures, and calculations.

An integrated plant data base is established by first organizing all plant activities, their data, and their interrelationships into a common plant data model. The data model provides a plan for the structure of the data base, which can then be implemented in whole or in part as needed. This common plant data model and its subsequent data base are illustrated in Fig 1 by the large box containing the data files. Each activity simply stores data in, or receives data from, the integrated data base. The interfaces between the activities and the integrated plant data base are illustrated in the figure by the vertical lines between the activity boxes and the large box representing the integrated plant data base.

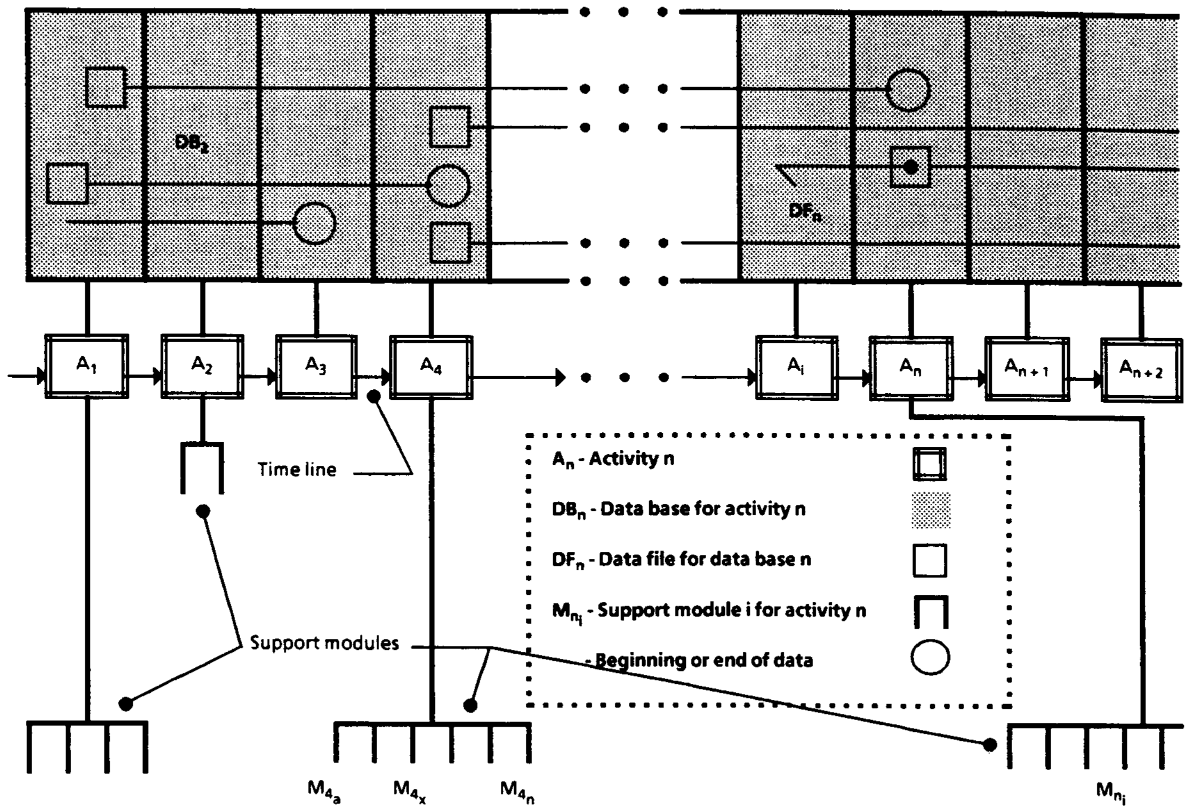

Figure 1—Concept Diagram of the Plant Information Network (PIN)

When an activity begins, certain data from previous activities is sometimes a required part of the data base of that later activity. To provide this required data flow, individual activities must be interconnected by an architecture that will associate an activity with any related activities in the PIN by the flow of data between them. This flow of data among activities, referred to as data flowpaths, provides a commonality among the activities and allows an exchange of information. The flowpaths, which link the activities together, are represented in the figure by the time line (lines with arrowheads) and the lines joining the data files (squares) to the end of data use (shown as circles) in the various activity databases. The exchange of information between activities is actually accomplished via interaction with the integrated plant data base.

4.1.3 CAE Application Development Practices

To implement CAE applications based on the PIN, sound software development practices must be followed. These concepts, known collectively as the software life cycle, address the techniques for software development from conception to the final release and maintenance of the software. Generally, a CAE application development project consists of six phases:

1) Preliminary project evaluation
2) Functional specification
3) Software design
4) Software implementation
5) Software verification and release
6) Project management

More information about the software life cycle can be found in IEEE Std 610.12-1990 [2].

4.1.4 Functional Specification

The functional specification is a formal description of the essential requirements for the application, including the information flow with other activities. It specifies the objectives of the application and the functions that will meet those objectives. The functional specification details the data model requirements and all functions, performance, inputs/outputs, and the like, so that the system design can be developed directly from it. This detail helps to ensure that interfaces with existing software, hardware, and manual systems are planned before coding begins.

Although the functional specification concentrates on the functions that must be incorporated into the system, it may also specify growth and expansion requirements. The software can be designed with future requirements of the application in mind, thereby eliminating the need to perform a costly redesign of the application later. More information on functional specification guidelines can be found in IEEE Std 830-1984 [4].

4.1.5 Common Plant Data Model

Applying these existing functional specification guidelines to CAE application development will result in good stand-alone applications, but they do not address the concept of application integration. When limited to a single activity, CAE applications cannot provide maximum benefits; only through integration with other activities can benefits be maximized. The key element for integrating CAE application is the use of a single, comprehensive plant data model that consolidates the types and structures of information used by the work activities performed over the life of the plant. This data model, combined with the various activities that use and exchange its data, forms the PIN that provides a foundation on which to build integrated CAE applications. The PIN serves as a mapping tool to integrate a particular application into the overall picture of the plant life cycle.

Using the PIN when designing and implementing CAE applications will give the designers the ability to make conscious decisions about data duplication and other implementation alternatives before implementing those interfacing applications. Given the number of activities involved in a generating plant, modular implementation of CAE applications maybe the only feasible course of action for a utility to follow. Therefore, the integration aspects of the PIN are best used during application development, not after.

4.2 Description of the PIN

This section explains the definition and structure of the PIN, tells how the PIN was formed, and outlines the scope and level of detail in the PIN.

4.2.1 Definition and Structure of the PIN

The PIN is a structure of plant information that integrates common data requirements across the generating plant life cycle, from site selection to decommissioning. This structure is based on the concepts presented in 4.1 and illustrated in Fig 1. The PIN consolidates the types and the structure of information used in activities performed throughout all phases of the life of a plant into a single, comprehensive plant data model. This data model, combined with a definition of the data requirements for each activity and the flow of data among activities, results in a network that clearly defines the flow of information throughout all phases of the life of a plant.

The PIN contains the following four major components:

1) *Activity list*—A list of all activities occurring throughout the life of a plant. A short description of each activity is included.
2) *Activity documentation packages*—Documentation that contains the activity scope, major data items, data relationships, interfaces to other activities, and a conceptual data model for the activity.
3) *Plant data model*—A compilation of all activity data models into one comprehensive model of plant data. It includes a list of all data names and definitions and the relationships among the data.
4) *Plant data flowpaths*—A list of activities sending and receiving each data item to show the flow of data between the activities.

These PIN components are presented in Appendixes C through H of EPRI Report NP-5159-Ms [1] and are described in detail in 4.2.2 through 4.2.5. These appendixes are listed here for convenience and are referred to in the remaining sections simply by the appendix name or letter.

4.2.1.1 Formation of the PIN

The generating-plant life cycle is divided into activities, the data used by individual activities is established, and these results are merged into a single network of plant data and plant activities called the PIN.

To determine a list of activities for a typical generating plant, the plant life cycle is divided according to the hierarchy shown in Fig 2.

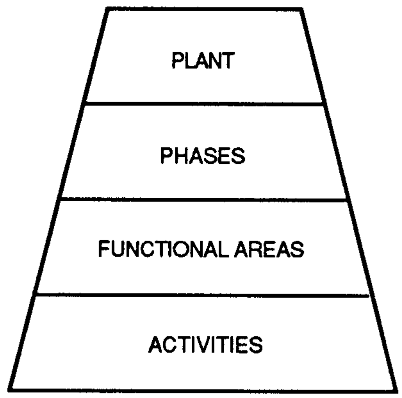

Figure 2—Hierarchy of the Plant Life Cycle

Fig 3 shows this hierarchy and includes the phases and examples of functional areas of this structure. The plant work processes are divided into five phases that represent the major stages of a generating-plant life cycle. The five phases are site selection, design, construction, operation, and decommissioning. This separation into phases implies movement along a time line. Each phase is divided into functional areas that organize the plant activities into broad functions. Within each functional area are the discrete activities that occur (and may occur) during the life cycle of the plant.

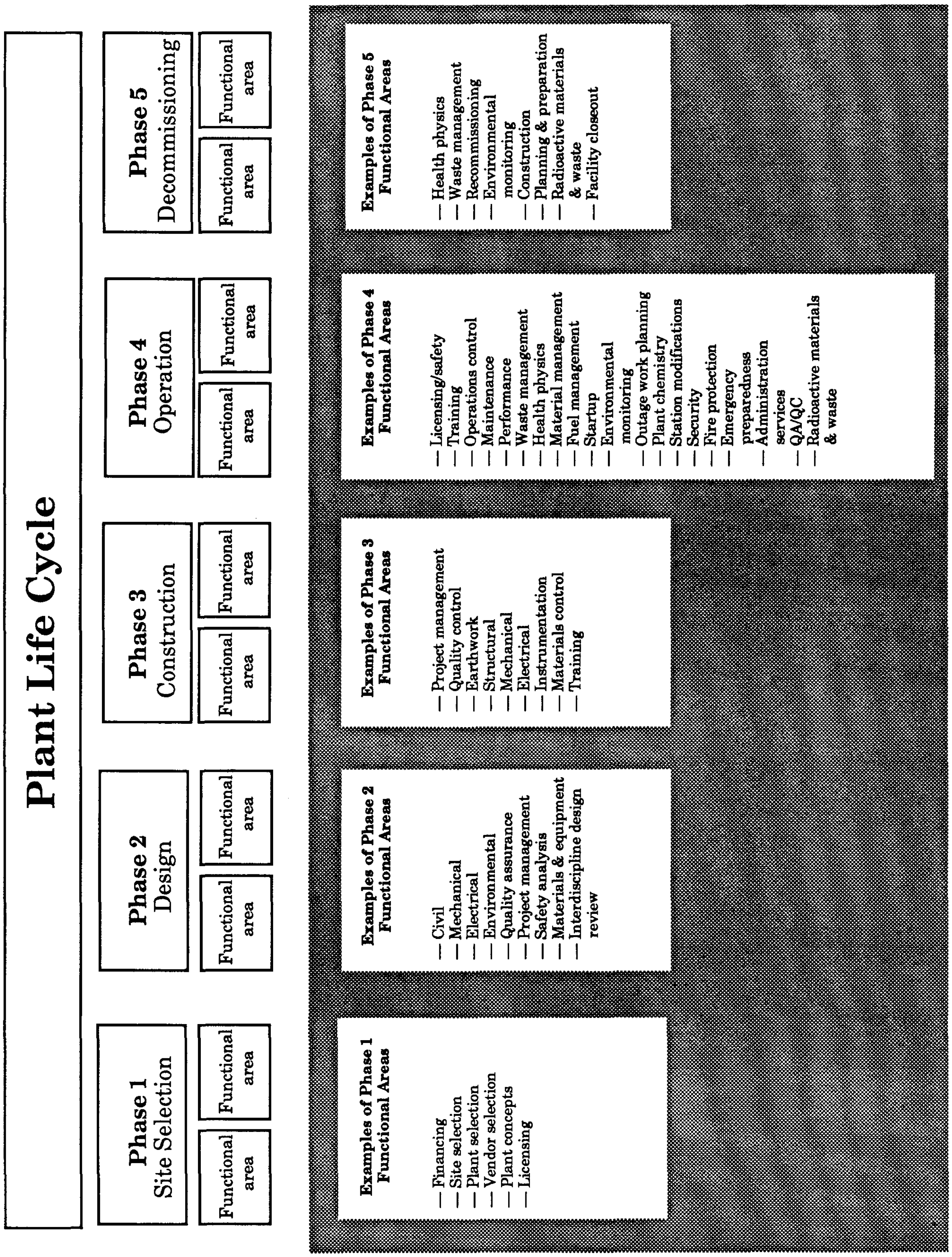

Figure 3—Plant Life-Cycle Phases

In general, each plant phase contains activities that are performed in a common time frame within the plant life cycle. Frequently, however, an activity can be active during a subsequent plant phase, as in a design activity performed for a modification to an operating plant. For this reason, the phase that an activity is listed under should not be taken as a strict time frame for performing the activity.

This division resulted in the identification of over 400 activities. The names and scopes of these activities were chosen according to various utility procedures, organizational structures, US Department of Energy and utility workflow studies, and guidance from several utilities and architect/engineer firms. A list of these activities is presented in Appendix C of EPRI Report NP-5159-Ms [1].

The results of individual activity investigations were merged to complete the PIN. This was accomplished by converting activity investigation results into a tabular form and resolving differences between activities in terms of data definitions, interfaces, and levels of detail. The results of merging these activity documentation packages are presented in a series of reports in Appendixes E–H.

The appendixes contain the results of the activity investigations, which are a subset of the total list of plant activities identified. Users of this recommended practice should contact the IEEE with further activity investigation for subsequent incorporation.[3] Consistency of activity investigation scope and detail shall be mandatory for inclusion in this recommended practice.

4.2.1.2 Scope and Level of Detail

The PIN includes over 400 activities that occur throughout the life of a generating plant. These activities are key links in the generating-plant life cycle and are common throughout the power generation industry. In this context of the PIN, plant modifications are considered to be reiterations of the original design and construction activities, and as such, are not listed as separate activities. Similarly, plant-life extension tasks are not addressed as separate activities in the plant life cycle.

The activity and data definitions presented in these guidelines are generic to ensure universal applicability for most types of generating plants and organizations using this information. In practice, different tasks within an activity may be performed by the utility, contractors, or both. However, the activity is presented in these guidelines as a continuous process without regard to who performs each task. Therefore, in many cases, the activity boundaries and data definitions will require some expansion and/or customization when developing computer implementations of these concepts. Instructions for customizing this information are given in 4.3.4.

Also, since the purpose of the PIN is to identify the plant data and data usage, the major emphasis in each activity investigation is on activity data contents, relationships between the data, and data interfaces to other activities, rather than on the process of performing the activity tasks. Brief descriptions of the activities are documented only to clarify their scope and boundaries in relation to other activities and to help in defining their data requirements.

4.2.2 Activity List

The activity list is a list of all activities defined by the scope of the PIN. This list is categorized by phase and functional area, and is supplemented by a list of activity short descriptions that help define the scope and boundaries of each activity. The activity list, including the activity short descriptions, is included as Appendix C of EPRI Report NP-5159-Ms [1].

Activities were individually numbered according to the numbering system shown in Fig 4.

[3]Instructions are included in 5.2.

Activity Number

2 E 21

where

The first character is the phase (2)
The second character is the functional area (E)
The third and fourth characters are the suffix (21)

Figure 4—Numbering System for the Plant Activities

For example, the activity number for the cable routing activity is 2E21. The first character of the four-character activity number represents the power plant phase in which the plant activity is listed (2 is the design phase). The second character identifies a functional area within the phase (E, in the design phase, represents the electrical functional area). The last two characters are a suffix that uniquely identifies the activity within the functional area.

Fig 5 is a sample page from the activity list (from Appendix C of EPRI Report NP-5159-Ms [1]) that shows activities for several functional areas within the design phase. The asterisk preceding the activity name indicates that the activity was researched and documented as one of the activities selected for detailed investigation. In this sample page, the cable routing activity (2E21) is shown as part of the electrical (2E) functional area within the design phase.

Fig 6 is a sample page from the activity short descriptions (also part of Appendix C). The activity short descriptions list is organized in the same sequence as is the activity list, which is by phase and functional area. This example shows several activity short descriptions from the Civil (2C) functional area within the design phase.

4.2.3 Activity Documentation Package

Each activity investigation is documented in an individual report called an activity documentation package (included in Appendix D of EPRI Report NP-5159-Ms [1]). These packages describe the scope, major tasks, data definitions, data relationships, and data interfaces at a general level. The documentation package contains the data and data relationships for an investigated activity. Those activities documented by an activity documentation package are identified in the activity list by an asterisk beside the activity name.

The activity documentation package for each activity consists of the following five major components:

1) Activity description
2) Activity process diagram
3) Activity data list
4) Activity entity-relationship diagram and table
5) Activity support modules

4.2.3.1 Activity Description

The activity description gives an overview of the activity, describes the activity and its scope, and delineates the boundaries and the major tasks of the activity. Additional information includes relevant background information, any restrictions or constraints on performing the activity, and the relative position of the activity in the generating-plant life cycle. It is provided to define the activities' relationships to other activities and thus to help determine the boundaries of the activity. Fig 7 is the activity description for the fire protection zones activity.

2. DESIGN

FUNCTIONAL AREA			ACTIVITY
2C CIVIL			
	01		SITE SEISMOLOGY AND GEOLOGY
	02	*	GENERAL ARRANGEMENT
	03		SEISMIC CRITERIA DEVELOPMENT
	04		ENGR/DESIGN CRITERIA DEVELOP
	05	*	ARCHITECTURAL DESIGN
	06	*	FLOOR RESPONSE SPECTRA DEVELOP
	07		ROADS & RAILROADS DESIGN
	08		EARTHWORK & DRAINAGE DESIGN
	09		FIRE PROTECTION CRITERIA
	10	*	FIRE PROTECTION ZONES
	11	*	STRUCT ANALYS/DESIGN CONCRETE
	12	*	STRUCT ANALYS/DES STRUCT STEEL
	13		STRUCT ANALYS/DES MISC STEEL
	14	*	TANK DESIGN
	15	*	EQUIP SEISMIC QUALIF/ANCHORAGE
	16	*	DAM DESIGN
	17		INTAKE/DISCHARGE STRUCTURES
	18		CCW PIPE DESIGN
	19		BURIED PIPE DESIGN
	20		EMBEDDED PIPING DESIGN
	21	*	PROTECTIVE COATINGS
	22		CRANES AND HOISTS DESIGN
	23		COAL HANDLING DESIGN
	24		COOLING TOWER DESIGN
2D ENVIRONMENTAL			
	01		METEOROLOGY STUDIES
	02		AIR QUALITY STUDIES
	03		GROUNDWATER STUDIES
	04		SURFACE WATER STUDIES
	05		BACKGROUND NOISE STUDIES
	06		AQUATIC ECOLOGY STUDIES
	07		TERRESTRIAL ECOLOGY STUDIES
	08		DEMOGRAPHY STUDIES
	09		AERIAL PHOTOGRAPHY
2E ELECTRICAL			
	01	*	AUX POWER SYS CONFIG & LAYOUT
	02		ENGR/DESIGN CRITERIA DEVELOP
	03	*	SWITCHING STATION LAYOUT
	04	*	CONTROL ROOM LAYOUT
	05	*	ELECTRICAL EQUIPMENT LAYOUT
	06	*	CABLE TRAY LAYOUT
	07	*	CABLE TRAY HANGER DESIGN
	08	*	I&C CONCEPTS/ENGINEERING
	09		I&C LOAD ASSIGNMENTS
	10		OPERATOR-AID-COMPUTER CONCEPTS
	11	*	OPERATOR-AID-COMPUTER DESIGN
	12	*	POWER LOAD ASSIGNMENT
	13	*	PROTECTIVE RELAYING & METERING
	14	*	EMERG POWER LOAD SEQUENCING
	15	*	DETAILED POWER SYSTEM DESIGN
	16	*	DETAILED CONTROL SYSTEM DESIGN
	17	*	PANEL/CABINET DESIGN
	18	*	POWER EQUIPMENT SIZING
	19	*	EQUIPMENT ENGINEERING
	20	*	CABLE SYSTEM DESIGN
	21	*	CABLE ROUTING
	22	*	FIRE DETECTION SYSTEM DESIGN
	23		SECURITY SYSTEM DESIGN
	24		TRACE HEATING DESIGN
	25		LIGHTING DESIGN
	26		ELECTRICAL GROUNDING DESIGN
	27		CATHODIC PROTECTION DESIGN
	28		LIGHTNING PROTECTION DESIGN
	29		COMMUNICATION SYSTEMS DESIGN

Figure 5—Sample Page From the Activity List

2C CIVIL

2C01 SITE SEISMOLOGY AND GEOLOGY

Perform studies of available literature and on-site geologic formations to define the regional and local geologic conditions for the site. Research and evaluate the historic earthquake records for the area to determine the potential for seismic activity at the plant site.

2C02 GENERAL ARRANGEMENT

Provide conceptual, preliminary, and final layout drawings for the entire generating plant considering maintenance accessibility, hoist requirements, monorail location requirements, shielding requirements, etc.

2C03 SEISMIC CRITERIA DEVELOPMENT

Develop the criteria to be followed and the methods to be used to seismically qualify plant structures, systems and components. Include identification of maximum theoretical horizontal and vertical ground acceleration, response spectra, stiffness factors, critical damping values, etc.

2C04 ENGR/DESIGN CRITERIA DEVELOPMENT

Identify the criteria to be followed in the design of the structures and systems of a power plant. Include applicable state and local building codes, industry standards, federal regulatory guides, etc.

2C05 ARCHITECTURAL DESIGN

Provide layout and planning of offices, warehouses and other personnel and maintenance support areas. Design and specify exterior wall and roofing materials, furniture, lab equipment, elevators, etc.

2C06 FLOOR RESPONSE SPECTRA DEVELOPMENT

Compute time histories at points of interest within the plant by: 1) developing a math model of the structure including stiffnesses and masses of the structural members and significant equipment attached to the structure; 2) performing a modal analysis of the math model based on appropriate ground motion time history; 3) determining modal responses of the structure; and 4) combining modal responses.

2C07 ROADS & RAILROADS DESIGN

Design temporary and permanent access roads and railways based on traffic volume, safety, terrain and drainage requirements. Include reconnaissance, preliminary and final location surveys, culvert designs and bridge designs as required.

Figure 6—Sample Page From the Activity Short Descriptions

Activity : FIRE PROTECTION ZONES Activity # : 2C10

1. ACTIVITY DESCRIPTION

The determination of fire protection zones involves the establishment of horizontal and vertical fire resistive divisions within a building for the purpose of minimizing the effects of fires. Proper selection of the zones results in the reasonable assurance of continued safe unit operation, minimal property loss and a reasonably safe environment for station personnel.

The activity begins with a complete review of pertinent project information such as detailed project description documents and conceptual general arrangement drawings. Also, applicable federal, state and local codes, regulations, and standards are identified as well as client and insurance carrier requirements.

Following completion of the information review and identification of applicable codes and regulations, a conceptual document that outlines fire protection separation requirements is developed. The document explains the philosophy for development of fire protection divisions and provides guidance for the determination of separation requirements for equipment and cable. Attributes such as equipment fire load (fuel contribution), monetary value, replacement time, sensitivity to the effects of fire, and redundancy are considered. Additionally, the strategy behind establishing the importance of the equipment or cable for continued safe operation of the unit is described.

Following development of the preliminary design information, a document that finalizes the fire protection separation requirements is developed. This document refines the established conceptual requirements and provides guidance for selection of fire suppression systems, fire detection systems, and fire resistive cable wrapping as a supplement to or in lieu of fire divisions.

Subsequent specifications and/or designs performed by the Fire Protection Zone activity include fire protection water supply, standpipe systems, fire suppression systems, and fire division walls, floors, hatches and doors. In addition, penetration fire stops and dampers and curb and/or floor drain requirements are determined. Fire extinguisher and hose locations are determined, emergency lighting is specified, and protection for selected structural steel items and cable tray supports is specified. Electrical cable requiring fire resistive wrap, alone or in conjunction with fire suppression and/or detection systems, is also identified.

The final step in establishing fire protection zones includes development of design drawings that illustrate the arrangement of fire protection zones within the plant's buildings, and creation of a project fire protection scope document that details the fire protection program as well as the characteristics of equipment, electrical cable, fire protection and fire detection within each zone.

Figure 7—Sample Activity Description of the Fire Protection Zones

4.2.3.2 Activity Process Diagram

The activity process diagram shows the general sequence of major tasks within an activity and represents the basic process required to complete an activity. It is used to clarify the scope of the activity and its relationships to other activities. This process diagram can be modified by the individual utility to incorporate any additional steps or task checkpoints as may be needed. Fig 8 is the activity process diagram for the fire protection zones activity.

4.2.3.3 Activity Data List

The activity data list identifies the major data items used by the activity, gives a definition for each data item, and lists other activities that provide or receive each data item. The list is in two parts, one for input data and one for output and internal data.

The input data portion of the list shows data items supplied by other activities and lists those activities from which the data are received. These other activities are not necessarily the originators of the data, but they are the source of the data for the documented activity. Fig 9 shows a sample input data page from the activity data list for the fire protection zones activity.

The output and internal data portion of the list shows output data items that are sent to other activities. Also included are internal data items that are defined as data items that are neither received from nor sent to other activities, but are originated in this activity for its own use and records. Since this internal data cannot be shown as an input from or output to another activity, the output and internal data list shows this as an output from the activity to itself. Fig 10 shows a sample output and internal data page from the activity data list for the fire protection zones activity.

The input data list and output data list may contain many of the same data items. One reason for this is that many activities refine data that are provided from another activity; for example, the activity that finalizes equipment locations may follow some other activity that has assigned preliminary locations. Another reason is that some input data and output data may be described with the same data item name even though the two are different components in the plant, as in updating some relay (DEVICE/INSTRUMENT) locations (output data) based on the meter (DEVICE/INSTRUMENT) locations (input data) from another activity. A third reason is that many data items are not created or updated by the activity but are closely related to other critical data being sent out. This relationship results in an activity passing along data received from other activities; the attribute then appears in both the input data list and the output data list.

A “created new” indicator in the output and internal data list is used to identify those data items that a given activity either creates or updates. Many times a data item name represents a combination of different data items being created, updated, or simply passed along to another activity. For example, an activity might create the locations of certain EMBEDMENTS, modify the locations of some EMBEDMENTS, and pass to another activity the locations of other EMBEDMENTS. If any updating or creating occurs for a certain data item for any subsequent activities, an asterisk is shown beside that data item. These asterisks therefore indicate that the activity must be able to manipulate the contents of certain data items.

Data items are represented in the PIN in an entity/attribute format. An entity is an object or subject about which an activity sends, receives, or records information. An attribute is a characteristic or property of interest about an entity. For example, the data item CABLE ESTIMATED LENGTH refers to the entity CABLE and to a characteristic of the cable, which is its length. Therefore, ESTIMATED LENGTH is an attribute of the entity CABLE. The numbering system used to assign entity and attribute numbers is shown in Fig 11.

ACTIVITY : FIRE PROTECTION ZONES

ACTIVITY # : 2C10

2. ACTIVITY PROCESS DIAGRAM

PAGE # : 1

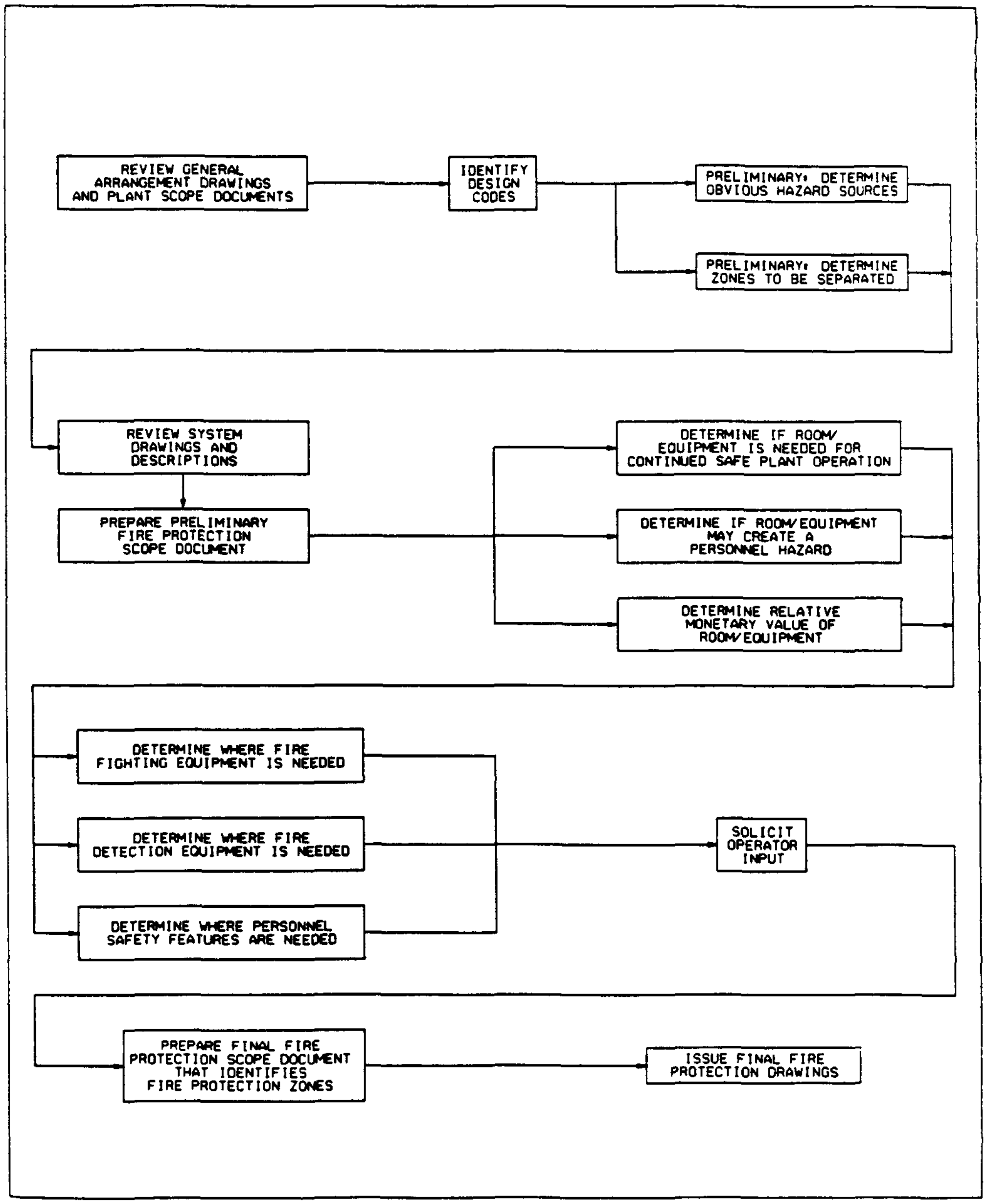

Figure 8—Sample Activity Process Diagram for the Fire Protection Zones Activity

ACTIVITY : FIRE PROTECTION ZONES — ACTIVITY # : 2C10

3. ACTIVITY DATA LIST — PAGE # : 1

3.1 INPUT DATA

ENTITY/ATTRIBUTE	DESCRIPTION	ACTIVITY THAT DATA WAS RECEIVED FROM
100-CABLE		
01-IDENTIFIER	UNIQUE IDENTIFIER	2E21-CABLE ROUTING
02-ROUTE	SEQUENCE OF ROUTE POINTS	2E21-CABLE ROUTING
16-IMPORTANCE	RELATIVE IMPORTANCE TO CONTINUED OPERATION/SAFE SHUTDOWN	2E20-CABLE SYSTEM DESIGN
25-FIRE PROTECTION CRITERIA	FIRE PROTECTION REQUIREMENTS FOR THE CABLE	2C09-FIRE PROTECTION CRITERIA
105-CABLE TYPE		
01-UTILITY PART NUMBER	UNIQUE IDENTIFIER FOR TYPE OF CABLE	2E20-CABLE SYSTEM DESIGN 2E21-CABLE ROUTING
300-PIPE LINE		
01-IDENTIFIER	UNIQUE IDENTIFIER OF A RUN OF PIPE OR TUBING	2M10-PIPING LAYOUT
02-LOCATION	LOCATION IN PLANT	2M10-PIPING LAYOUT
23-FIRE PROTECTION CRITERIA	FIRE PROTECTION DESIGN CRITERIA	2C09-FIRE PROTECTION CRITERIA
303-PROCESS FLUID		
01-IDENTIFIER	IDENTIFIER FOR A VOLUME OF CONSTANT PRESSURE, TEMPERATURE, AND CONTENT	2M02-PROCESS SYSTEM CONCEPTS 2M04-PROCESS SYSTEM DESIGN
04-DESCRIPTION	GENERAL DESCRIPTION OF FLUID	2M02-PROCESS SYSTEM CONCEPTS 2M04-PROCESS SYSTEM DESIGN
21-COMBUSTIBILITY	FLAMMABILITY OF FLUID	2M02-PROCESS SYSTEM CONCEPTS 2M04-PROCESS SYSTEM DESIGN
310-DEVICE/INSTRUMENT		
01-IDENTIFIER	UNIQUE IDENTIFIER	2M06-EQUIPMENT/VALVE SPECIFICATIONS
04-DESCRIPTION	GENERAL DESCRIPTION	2M06-EQUIPMENT/VALVE SPECIFICATIONS
05-FUNCTION	PURPOSE OF INSTRUMENT	2M06-EQUIPMENT/VALVE SPECIFICATIONS
06-NUCLEAR SAFETY CLASS	CODE FOR APPLICATION OF NUCLEAR SAFETY CRITERIA	2M06-EQUIPMENT/VALVE SPECIFICATIONS
49-DESIGN SPEC	DOCUMENT NUMBER	2E22-FIRE DETECTION SYSTEM DESIGN
51-ENVIRON SENSITIVITY	SUSCEPTIBILITY TO DAMAGE FROM FIRE OR WATER SPRAY	2M06-EQUIPMENT/VALVE SPECIFICATIONS
52-IMPORTANCE	RELATIVE IMPORTANCE TO CONTINUED SAFE OPERATION/SAFE SHUTDOWN	2M06-EQUIPMENT/VALVE SPECIFICATIONS
405-INSULATION TYPE		
01-UTILITY PART NUMBER	IDENTIFIER FOR TYPE OF INSULATION	2C05-ARCHITECTURAL DESIGN 2M10-PIPING LAYOUT 2M30-HVAC DETAILED DESIGN
04-DESCRIPTION	GENERAL DESCRIPTION OF SHIELDING OR INSULATION	2M30-HVAC DETAILED DESIGN

Figure 9—Sample of the Input Data for the Fire Protection Zones Activity

ACTIVITY : FIRE PROTECTION ZONES ACTIVITY # : 2C10

3. ACTIVITY DATA LIST PAGE # : 7

3.2 OUTPUT AND INTERNAL DATA <* - DATA THAT IS CREATED NEW>

ENTITY/ATTRIBUTE	DESCRIPTION	SUBSEQUENT ACTIVITIES THAT REQUIRE THIS DATA
105-CABLE TYPE		
11-FLAME SPREAD	RATE AT WHICH FLAME SPREADS ALONG THE CABLE MEASURED IN UNITS LENGTH PER UNIT TIME	2C10-FIRE PROTECTION ZONES
405-INSULATION TYPE		
* 01-UTILITY PART NUMBER	IDENTIFIER FOR TYPE OF INSULATION	2C05-ARCHITECTURAL DESIGN 2E20-CABLE SYSTEM DESIGN
12-FLAME SPREAD	RATE AT WHICH FLAME SPREADS ALONG THE INSULATION MEASURED IN UNITS LENGTH PER UNIT TIME	2C10-FIRE PROTECTION ZONES
13-SMOKE DEVELOPMENT	RATE AT WHICH THE INSULATION MAY ADD SMOKE TO A FIRE	2C10-FIRE PROTECTION ZONES
14-INDUSTRY STANDARDS	DESIGN GUIDELINES	2C10-FIRE PROTECTION ZONES
501-SLAB		
01-IDENTIFIER	UNIQUE IDENTIFIER	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN 2E20-CABLE SYSTEM DESIGN 2M30-HVAC DETAILED DESIGN
02-LOCATION	PHYSICAL LOCATION IN PLANT	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN
03-DIMENSIONS	PHYSICAL DIMENSIONS OF SLAB	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN
05-FUNCTION	PURPOSE OF SLAB	2C05-ARCHITECTURAL DESIGN
503-WALL		
01-IDENTIFIER	UNIQUE IDENTIFIER	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN 2E20-CABLE SYSTEM DESIGN 2M30-HVAC DETAILED DESIGN
* 02-LOCATION	PHYSICAL LOCATION IN PLANT	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN
* 03-DIMENSIONS	PHYSICAL DIMENSIONS OF WALL	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN
* 05-FUNCTION	PURPOSE OF WALL	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN
505-MISCELLANEOUS STRUCTURE		
01-IDENTIFIER	UNIQUE IDENTIFIER	2C02-GENERAL ARRANGEMENT 2C05-ARCHITECTURAL DESIGN 2E20-CABLE SYSTEM DESIGN 2M30-HVAC DETAILED DESIGN
506-OPENING		
01-IDENTIFIER	IDENTIFIER FOR OPENING IN SLAB, WALL, ETC.	2C05-ARCHITECTURAL DESIGN 2C11-STRUCT ANALYS/DESIGN CONCRETE
02-LOCATION	LOCATION IN PLANT AND IN WALL, SLAB, ETC.	2C11-STRUCT ANALYS/DESIGN CONCRETE

Figure 10—Sample of the Output and Internal Data for the Fire Protection Zones Activity

Data Item Number

1 0 0 2 1

where

The first three characters are the entity
The last two characters are the attribute

Figure 11—Example of the Data Item Numbering System for the Entity/Attribute Format

In Fig 11, data item number 100–21 is CABLE ESTIMATED LENGTH. The three-character entity number, 100, uniquely defines the entity CABLE. The two-character attribute number, 21, identifies the attribute ESTIMATED LENGTH for CABLE. This two-character attribute number is unique only within a given entity; attribute number 21 may represent an attribute other than ESTIMATED LENGTH for another entity.

4.2.3.4 Activity Entity-Relationship (E-R) Diagram and Table

The entity-relationship (E-R) diagram and an entity-relationship (E-R) table are included in each activity documentation package to present a conceptual data model for each activity. Figs 12 and 13 show the E-R diagram and E-R table, respectively, for the fire protection zone activity. This diagram and table define the activity data base by showing the entities, attributes, and relationships between entities for each activity. The E-R diagrams are included in Appendix D of EPRI Report NP-5159-Ms [1].

The E-R diagram is a generally accepted method of showing the organization of data. For each activity documentation package, the diagram represents all entities and attributes for the activity and shows the same entities and attributes listed in the activity data list. In addition, the E-R diagram shows how entities are related or cross-referenced according to their use in the activity.

For illustrative purposes, Fig 14 is a portion of an E-R diagram for cable pulling information. The definitions below briefly explain the contents of an E-R diagram. Details of specialized techniques used in the diagrams, such as REF ENTITY and ID relationship are given in 4.2.6.

1) An *entity set* is a collection of like items or subjects that can be individually identified and about which information is recorded. Entity sets are represented by rectangles in an E-R diagram. Entity sets shown in Fig 14 are ELECTRICAL EQUIPMENT, CABLE, CABLE TYPE, and CABLE REEL.
2) An *attribute* describes the characteristics, facts, or properties of an entity or entity set. Attributes are shown on the E-R diagram as ellipses. A key attribute uniquely defines one occurrence of an entity within an entity set. Key attributes are underlined on an E-R diagram and are described as a unique identifier in the description of the attribute. In Fig 14, the entity set CABLE has four attributes: identifier, route, pulled status, and estimated length. The "identifier" attribute is underlined to indicate that it is a key attribute of CABLE. This means that every cable in the plant is uniquely identified by its identifier.
3) A *relationship* describes the specific association that exists between two entity sets. A relationship between two entity sets is represented by a diamond connecting the two entity symbols in an E-R diagram. The example in Fig 14 contains the relationship IS CONNECTED TO, which represents a specific cross-reference between cables and electrical equipment. In the example, the following relationships are shown:

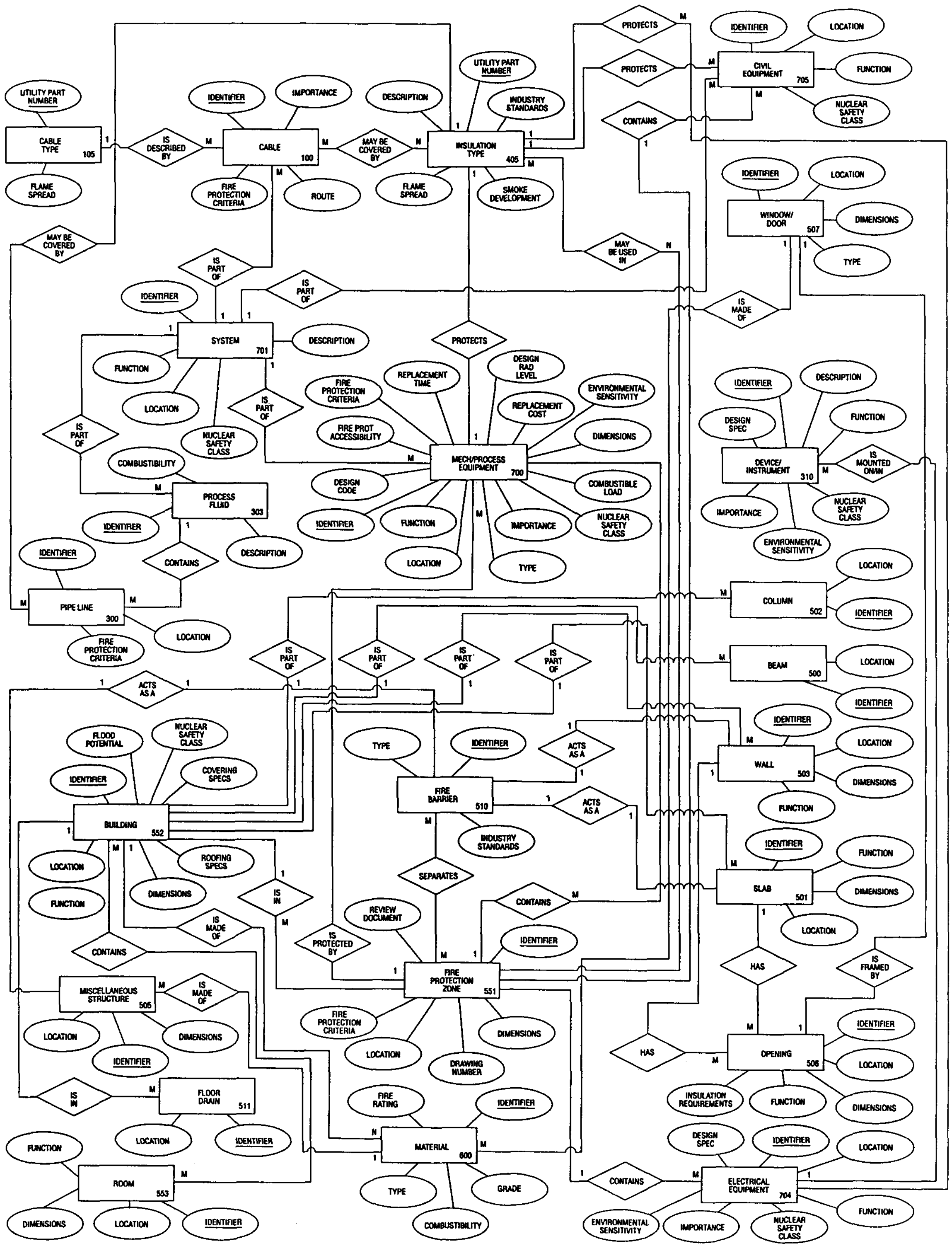

Figure 12—Sample E-R Diagram for the Fire Protection Zones Activity

CABLE	IS DESCRIBED BY	CABLE TYPE
CABLE	IS PULLED FROM	CABLE REEL
CABLE	IS CONNECTED TO	ELECTRICAL EQUIPMENT
CABLE TYPE	DESCRIBES	CABLE REEL

4) *Cardinality* defines the number of entities in one entity set that can be simultaneously related to an entity in another entity set. Cardinality is shown on the E-R diagram as one (1) or many (M or N) on each side of the relationship. The cardinality assigned to the other entity set always represents how many of the other entity set can be associated with a single occurrence in the first entity set.
For example, CABLE has a many-to-one (M-1) relationship to CABLE TYPE because many cables can be described by a single cable type, but only one cable type can describe a single cable.
Similarly, there is a many-to-many (M-N) relationship between CABLE and ELECTRICAL EQUIPMENT because many cables can be connected to a single piece of electrical equipment, and many pieces of electrical equipment can be connected to a single cable (possibly one at each end of the cable). A many-to-many relationship is always shown as M-N; there is no significance to which entity shows the M symbol and which shows the N symbol.
One feature of defining cardinality for each activity is that different activities may show different cardinalities on the same relationship because the activities may be addressing different items in the same entity set. For example, the relationship IS ATTACHED TO between ELECTRICAL EQUIPMENT and MECH/PROCESS EQUIPMENT is considered to be one-to-one in some activities and many-to-many in others because the different activities can be referring to different pieces of equipment in the plant that are represented by the same entity names.

Fig 13 is an E-R table for the fire protection zones activity. Like the E-R diagram, this table shows all entities and entity-relationships for the activity. This table does not show attributes; however, activity attributes are easily found by referring to the activity data list. An equivalent E-R diagram can be easily redrawn for an activity by using the E-R table and the activity data list.

ACTIVITY : FIRE PROTECTION ZONES ACTIVITY # : 2C10

4. ENTITY RELATIONSHIPS PAGE # : 1

4.2 ENTITY RELATIONSHIP TABLE

ENTITY	RELATIONSHIP	ENTITY	CARDINALITY	ID	REF ENTITY
100-CABLE	IS DESCRIBED BY	105-CABLE TYPE	M-1		
100-CABLE	MAY BE COVERED BY	405-INSULATION TYPE	M-N		
100-CABLE	IS PART OF	701-SYSTEM	M-1		
300-PIPE LINE	CONTAINS	303-PROCESS FLUID	M-1		
300-PIPE LINE	MAY BE COVERED BY	405-INSULATION TYPE	M-N		
303-PROCESS FLUID	IS PART OF	701-SYSTEM	M-1		
310-DEVICE/INSTRUMENT	IS MOUNTED ON/IN	704-ELECTRICAL EQUIPMENT	M-1		
405-INSULATION TYPE	MAY BE USED IN	551-FIRE PROTECTION ZONE	M-N		
405-INSULATION TYPE	PROTECTS	700-MECH/PROCESS EQUIPMENT	1-M		
405-INSULATION TYPE	PROTECTS	704-ELECTRICAL EQUIPMENT	1-M		
405-INSULATION TYPE	PROTECTS	705-CIVIL EQUIPMENT	1-M		
500-BEAM	IS PART OF	552-BUILDING	M-1		
501-SLAB	HAS	506-OPENING	1-M		
501-SLAB	ACTS AS A	510-FIRE BARRIER	1-1		
501-SLAB	IS PART OF	552-BUILDING	M-1		
502-COLUMN	IS PART OF	552-BUILDING	M-1		
503-WALL	HAS	506-OPENING	1-M		
503-WALL	ACTS AS A	510-FIRE BARRIER	1-1		
503-WALL	IS PART OF	552-BUILDING	M-1		
505-MISCELLANEOUS STRUCTURE	ACTS AS A	510-FIRE BARRIER	1-1		
505-MISCELLANEOUS STRUCTURE	IS MADE OF	600-MATERIAL	M-1		
506-OPENING	IS FRAMED BY	507-WINDOW/DOOR	1-1		
507-WINDOW/DOOR	IS MADE OF	600-MATERIAL	M-1		
510-FIRE BARRIER	SEPARATES	551-FIRE PROTECTION ZONE	M-N		
511-FLOOR DRAIN	IS IN	552-BUILDING	M-1		
551-FIRE PROTECTION ZONE	IS IN	552-BUILDING	M-1		
551-FIRE PROTECTION ZONE	CONTAINS	700-MECH/PROCESS EQUIPMENT	1-M		
551-FIRE PROTECTION ZONE	IS PROTECTED BY	700-MECH/PROCESS EQUIPMENT	1-M		
551-FIRE PROTECTION ZONE	CONTAINS	704-ELECTRICAL EQUIPMENT	1-M		
551-FIRE PROTECTION ZONE	CONTAINS	705-CIVIL EQUIPMENT	1-M		
552-BUILDING	CONTAINS	553-ROOM	1-M		
552-BUILDING	IS MADE OF	600-MATERIAL	M-N		
700-MECH/PROCESS EQUIPMENT	IS PART OF	701-SYSTEM	M-1		

Figure 13—Sample Activity E-R Table for the Fire Protection Zones Activity

The entity relationships and cardinality of the example shown in Fig 14 results in the E-R table shown with it.

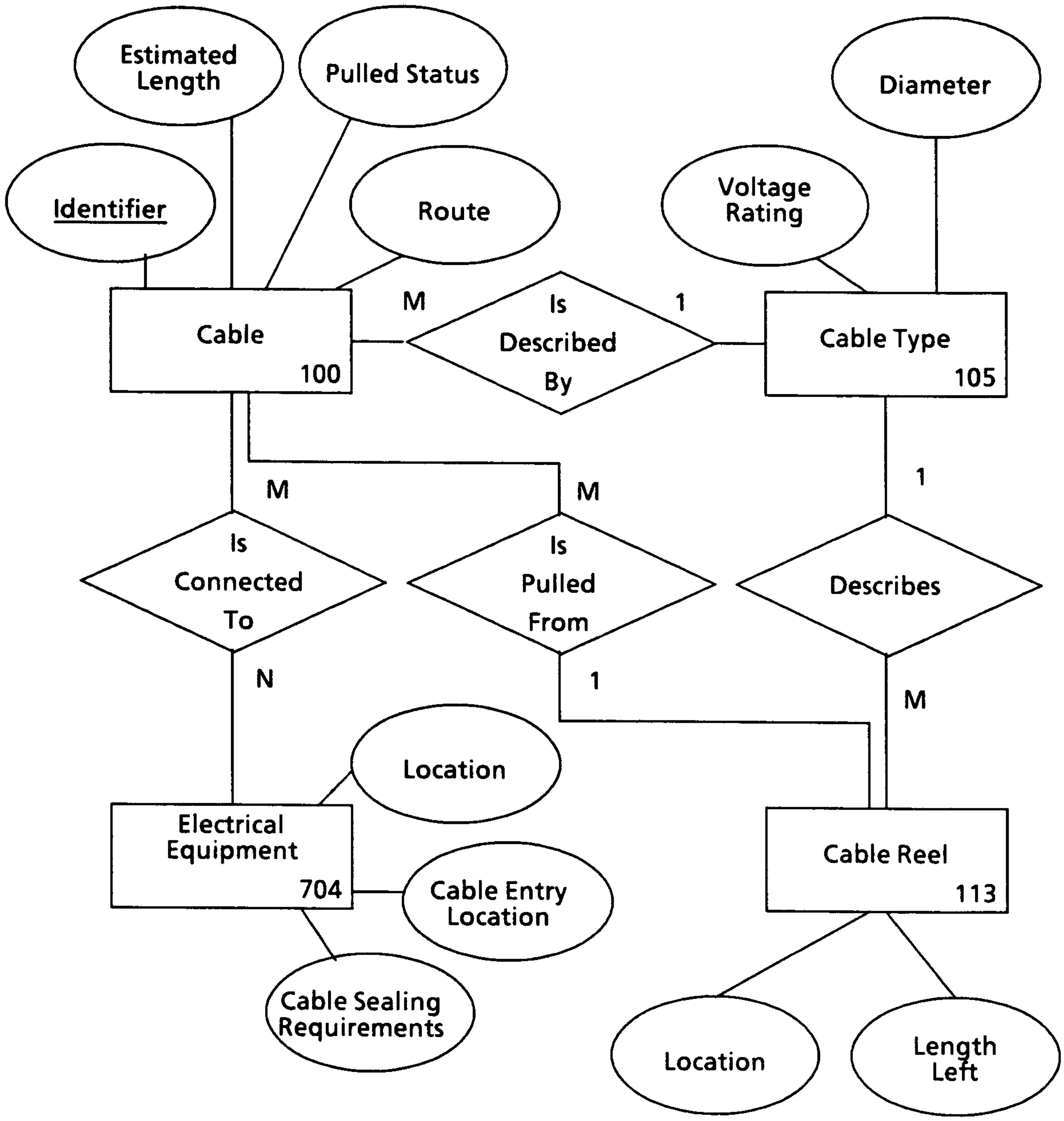

Figure 14—Example of a Portion of an E-R Diagram and Table

Since the phrasing of a relationship depends on the order of the entities, the phrase is always defined to read from the entity with the lower entity number to the entity with the higher number. For example, since the CABLE entity number is 100 and the CABLE TYPE entity number is 105, an appropriate phrase is "CABLE" "IS DESCRIBED BY" "CABLE TYPE." If the entity numbers were reversed, the appropriate phrase would be "CABLE TYPE" "DESCRIBES" "CABLE."

4.2.3.5 Activity Support Modules

The activity support modules section of the activity documentation package presents an example list of typical procedures, regulations, computer programs, and other operators on the activity data. Support modules influence the way in which data is handled in an activity by providing guidance, restrictions, or tools for manipulating or controlling the values of various data items and by providing guidance or restrictions for performing the activity tasks. This section is included in the activity documentation package to help define the activity scope and boundaries so that the activity data base can be determined. Fig 15 is the activity support modules list for the fire protection zones activity.

Activity : FIRE PROTECTION ZONES Activity # : 2C10

5. ACTIVITY SUPPORT MODULES

BUILDING CODES

The BUILDING CODES (local, state, and national) provide requirements concerning fire exit locations and quantity, and fire barrier locations and materials. The requirements specified by the BUILDING CODES depend on the building's construction materials, function, and personnel requirements.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION STANDARDS

The OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION STANDARDS (OSHA) specify fire exit and fire barrier requirements such as location, quantity, fire rating, and material suitability. The OSHA requirements depend on building function and personnel requirements.

CODE OF FEDERAL REGULATIONS

The CODE OF FEDERAL REGULATIONS includes specifications for fire barrier requirements at operating stations. Separation of redundant safety systems to preclude total loss of safe shutdown capabilities is emphasized.

Figure 15—Sample of the Activity Support Modules for the Fire Protection Zones Activity

4.2.3.6 Additional Activity Data List for Undocumented Activities

Documented activities can identify data flowpaths to and from any activity, regardless of whether the other activity is documented. Partial activity data lists are automatically generated for some undocumented activities. These partial listings are especially useful as a starting point for investigating undocumented activities. They are presented in the same format as are the activity data lists included in the activity documentation package. Appendix E of EPRI Report NP-5159-Ms [1] contains these partial activity data lists for undocumented activities.

4.2.4 Plant Data Model

The plant data model portion of the PIN describes the major data and relationships among the data for a typical generating plant. The process used to form the plant data model from the activity documentation packages was conversion of the entity relationships to tabular form; assignment of numbers to the data entities and attributes; and a merger of the data names, data definitions, and data relationships into a single model.

The two major components of the PIN plant data model are the data list and the E-R report. The data list is the combined list of all data entities and attributes identified in the individual activity data lists. The E-R report shows all relationships among all entities as identified by the individual activity E-R diagrams.

4.2.4.1 Plant Data List

The data list identifies all PIN entities and attributes, with a definition of each attribute. Fig 16 shows a sample page from this data list.

The data list provides a single index of entities and attributes used in the PIN. The report lists entries for entity number and name, attribute number and name, and description of the attribute. The report is sorted by entity number and by attribute number within the entity.

At the beginning of the report are two short indexes to assist users in locating entities in the PIN:

1) A list of entities sorted by the entity number provides a short list where similar or related entities are generally grouped by function.
2) A list of entities sorted alphabetically by entity name allows the user to find the number of an entity when the entity name is known.

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PLANT DATA MODEL

DATA LIST

DATA ITEM

ENTITY NUMBER AND NAME	ATTRIBUTE NUMBER AND NAME	DESCRIPTION
100 - CABLE		
	01 - IDENTIFIER	UNIQUE IDENTIFIER
	02 - ROUTE	SEQUENCE OF ROUTE POINTS
	06 - NUCLEAR SAFETY CLASS	NUCLEAR SAFETY RELATED
	11 - CLASS	POWER, CONTROL OR INSTRUMENTATION
	12 - TRAIN/CHANNEL	SEPARATION CLASS
	16 - IMPORTANCE	RELATIVE IMPORTANCE TO CONTINUED OPERATION/SAFE SHUTDOWN
	21 - ESTIMATED LENGTH	LENGTH ESTIMATED FROM THE PLANT GEOMETRY
	22 - SPECIAL ROUTING CRITERIA	SPECIAL ROUTE CONSIDERATIONS FOR FIRE PROTECTION, PLANT SHUTDOWN, ETC.
	23 - ACTUAL MAXIMUM TENSION	MAXIMUM TENSION APPLIED TO THE CABLE WHILE PULLING
	24 - SPECIAL PULLING INSTR	SPECIAL PULLING INSTRUCTION NOTES
	25 - FIRE PROTECTION CRITERIA	FIRE PROTECTION REQUIREMENTS FOR THE CABLE
	31 - PULLED STATUS	WHETHER THE CABLE HAS BEEN PULLED
	32 - ACTUAL LENGTH	ACTUAL LENGTH OF CABLE PULLED
101 - CABLE RACEWAY TYPE		
	01 - UTILITY PART NUMBER	UNIQUE IDENTIFIER FOR TYPE OF CABLE TRAY, CONDUIT, ETC.
	03 - DIMENSIONS	STANDARD TYPE PHYSICAL DIMENSIONS
	04 - DESCRIPTION	GENERAL DESCRIPTION OF RACEWAY TYPE (TRAY, CONDUIT, ETC.)
	06 - NUCLEAR SAFETY QUALIF	CODE FOR WHETHER QUALIFIED FOR NUCLEAR SAFETY APPLICATIONS
	07 - TYPE	GENERAL TYPE OF RACEWAY (CABLE TRAY, CONDUIT, SLEEVE, ETC.)

Figure 16—Sample Page From the PIN Data List

4.2.4.2 Plant E-R Report

The E-R report lists all relationships to an entity and the activity from which the relationship was identified. If the relationship is used by more than one activity, it is repeated for each activity. Another characteristic of the E-R report is that the relationships are always phrased so that the relationship reads from the entity with the lower number to the entity with the higher number. Also, since every relationship is between two entities, each relationship is listed twice in this report--once under each entity that is part of the relationship.

Fig 17 shows a sample page from the report, which is sorted by entity number. The E-R report has columns for the first entity of the relationship, for relationship (the phrase describing the association between entities), for the second entity of the relationship, for cardinality (how entities are paired between entity sets), and for the activity in which the relationship was defined. Two columns on the report, labeled "ID" and "REF ENTITY," refer to special relationships and are explained in 4.2.6.

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PLANT DATA MODEL

ENTITY RELATIONSHIPS

554 - RADIATION ZONE <CONTINUED>

ENTITY	RELATIONSHIP	ENTITY	CARDINALITY	ID	REF ENTITY	ACTIVITY
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			2M14
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			2M24
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4H06
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4H07
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4N01
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4N02
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4N03
310 - DEVICE/INSTRUMENT	IS IN	554 - RADIATION ZONE	M-1			4X09
310 - DEVICE/INSTRUMENT	MONITORS	554 - RADIATION ZONE	M-1			2M22
331 - PIPE S/R	IS IN	554 - RADIATION ZONE	M-1			4Y07
505 - MISCELLANEOUS STRUCTURE	IS IN	554 - RADIATION ZONE	M-1			2C02
505 - MISCELLANEOUS STRUCTURE	IS IN	554 - RADIATION ZONE	M-1			2M24
506 - OPENING	IS IN	554 - RADIATION ZONE	M-N			2C02
506 - OPENING	IS IN	554 - RADIATION ZONE	M-N			2E06
506 - OPENING	IS IN	554 - RADIATION ZONE	M-N			2M24
550 - ALLOCATED SPACE	IS IN	554 - RADIATION ZONE	M-1			2C21
550 - ALLOCATED SPACE	IS IN	554 - RADIATION ZONE	M-1			2E11
550 - ALLOCATED SPACE	IS IN	554 - RADIATION ZONE	M-1			2M22
550 - ALLOCATED SPACE	IS IN	554 - RADIATION ZONE	M-1			2M28
553 - ROOM	IS IN	554 - RADIATION ZONE	M-1			4H06
553 - ROOM	IS IN	554 - RADIATION ZONE	M-1			4H07
554 - RADIATION ZONE	CONTAINS	557 - RADIATION HOT SPOT	1-M			2M24
554 - RADIATION ZONE	CONTAINS	557 - RADIATION HOT SPOT	1-M			4H06
554 - RADIATION ZONE	CONTAINS	557 - RADIATION HOT SPOT	1-M			4H07
554 - RADIATION ZONE	UNDERGOES	606 - RADIATION SURVEY	1-M			4H06
554 - RADIATION ZONE	UNDERGOES	606 - RADIATION SURVEY	1-M			4H07
554 - RADIATION ZONE	CONTAINED	627 - RADIATION SAMPLE	1-M			4H06
554 - RADIATION ZONE	CONTAINED	627 - RADIATION SAMPLE	1-M			4H07
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2C02
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2C14
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2E06
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2M10
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2M22
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2M24
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			2M32
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			4H06
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			4H07
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			4X09
554 - RADIATION ZONE	CONTAINS	700 - MECH/PROCESS EQUIPMENT	1-M			4Y07
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			2C02
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			2E05
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			2E06
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			2E19
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			2M32
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			4H06
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			4N01
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			4N02
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			4N03
554 - RADIATION ZONE	CONTAINS	704 - ELECTRICAL EQUIPMENT	1-M			4X09

Figure 17—Sample Page From the E-R Report

4.2.5 Plant Data Flowpaths

The plant data flowpaths portion of the PIN shows the flow of data between activities. This portion of the PIN was formed by combining all data flowpaths identified in the individual activity data lists. The data flowpaths are presented in a report called the data usage list. Fig 18 shows a sample page from the data usage list.

A flowpath in the PIN consists of the activity sending the data, the data item that is sent (in the case of internal data, the sending and receiving activity are the same), and the activity receiving the data item. An example of some of the flowpaths from the activity data list of Fig 10 is shown in Table 1.

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PLANT DATA FLOWPATHS
DATA USAGE LIST

DATA ITEM NUMBER AND NAME	ACTIVITIES SENDING DATA ITEM		ACTIVITIES RECEIVING DATA ITEM
** CONTINUED **			
100-21 CABLE	ESTIMATED LENGTH		
	2E21 - CABLE ROUTING	TO	3D06 - CABLE PULLING
100-22 CABLE	SPECIAL ROUTING CRITERIA		
	2E01 - AUX POWER SYS CONFIG & LAYOUT	TO	2E20 - CABLE SYSTEM DESIGN
	2E20 - CABLE SYSTEM DESIGN	TO	2E15 - DETAILED POWER SYSTEM DESIGN
	2E20 - CABLE SYSTEM DESIGN	TO	2E16 - DETAILED CONTROL SYSTEM DESIGN
	2E20 - CABLE SYSTEM DESIGN	TO	2E21 - CABLE ROUTING
	2E21 - CABLE ROUTING	TO	3D06 - CABLE PULLING
	3D06 - CABLE PULLING	TO	3D04 - TRAY/CONDUIT ERECTION
100-23 CABLE	ACTUAL MAXIMUM TENSION		
	3D06 - CABLE PULLING	TO	3D06 - CABLE PULLING
100-24 CABLE	SPECIAL PULLING INSTR		
	2E21 - CABLE ROUTING	TO	3D06 - CABLE PULLING
100-25 CABLE	FIRE PROTECTION CRITERIA		
	2C09 - FIRE PROTECTION CRITERIA	TO	2C10 - FIRE PROTECTION ZONES
100-31 CABLE	PULLED STATUS		
	3D06 - CABLE PULLING	TO	2E21 - CABLE ROUTING
	3D06 - CABLE PULLING	TO	2P03 - PARTS/EQUIPMENT ORDERING
	3D06 - CABLE PULLING	TO	3D07 - CABLE TERMINATION
100-32 CABLE	ACTUAL LENGTH		
	3D06 - CABLE PULLING	TO	3G11 - MATERIAL ALLOCATION

Figure 18—Sample Page From the Data Usage List for the Fire Protection Zones Activity

Table 1—Tabulation of Data Flowpaths

Activity Sending Data	Data Item Being Sent	Activity Receiving Data
2C10	10511	2C10
2C10	40501	2C05
2C10	40501	2E20
2C10	40512	2C10
2C10	40513	2C10
2C10	40514	2C10
2C10	50101	2C02
2C10	50101	2C05
2C10	50101	2E20
2C10	50101	2M30

After merging the flowpaths from the individual activity documentation packages, the flowpath information can be sorted either by the activities (as in the activity documentation packages) or by the data item involved in the flowpath (as in the data usage list). The data usage list shows all flowpaths identified for each data item in the PIN, which makes it possible to analyze how each attribute is being sent among the various plant activities.

4.2.6 Special Techniques Used in the PIN

The following paragraphs explain some special techniques used for modeling activity data and flowpaths in the PIN. An understanding of these techniques is essential for understanding and finding information in the PIN and for customizing the PIN.

4.2.6.1 Special Activities

Special activity numbers such as SUPP, MANF, and NRC have been added to the PIN to show interfaces to organizations beyond the typical plant utility/contractor activities.

The activity SUPP represents a supplier or vendor that sends information to and receives information from the plant activities. Similarly, MANF represents a manufacturer of plant components or supplies. NRC allows the PIN to show flowpaths of data to and from the US Nuclear Regulatory Commission.

Another activity, ALL, was set up to show flowpaths to and from the document/records management activity (4D02). This activity can send or receive data from any activity in the plant life cycle, and it is not meaningful for the PIN to list all activities for the flowpaths in this case.

These special activities, which do not appear in the activity list, were added to the PIN to accommodate important activity interfaces. Other activities can be added when customizing the PIN for individual organization implementation.

4.2.6.2 Key Attributes

A key attribute is an attribute used to define one entity within an entity set uniquely. For example, the key attribute for the CABLE entity set is “identifier.” A cable identifier distinguishes one cable from all other cables for the plant. Key attributes are assigned the attribute number “01,” underlined on the E-R diagram, and described as a unique identifier in the description of the attribute.

A key attribute of an entity will have one of two different names: "identifier" or "utility part number." The "identifier" attribute is used on those entity sets that directly relate to individual entity occurrences in a power plant, such as cable, device, column, events, system, and action performed. The "utility part number" attribute is used as the key attribute for "type" entity sets such as cable type, device/instrument type, catalog item, load type, and pipe device type. Although the same name could have been used as the key attribute for all entity sets, having two different names helps to distinguish between these two kinds of entity sets.

All entity sets in the PIN have a key attribute except certain entity sets whose identities depend on related entities. A subset entity takes on the unique identifier and other common attributes of its parent entity set. Other entity sets, using ID relationships, obtain their identity from related entities (such as the UNIT/EVENT REACTION entity, whose identity comes from a UNIT and an EVENT).

4.2.6.3 ID Relationships

An ID relationship is one in which the identity of one of the entity sets is determined by the related entity set or sets. ID relationships are denoted by the letters "ID" on the relationship symbol on an E-R diagram and are also indicated by the letters "ID" under the column labeled "ID" in the activity E-R table or in the E-R report. One characteristic of an ID relationship is that one entity of the relationship has a key attribute and the other does not have one (because it uses the identity of the first entity).

An example of an ID relationship is the case where an entity is defined by a pair of other entities. The entity set UNIT/EVENT REACTION describes the response of a single unit to a single event. Attributes of this entity set include MODE, which is the operating mode of the unit at the time of the event, OUTPUT, which describes the unit output level at the time of the event, and LOST PRODUCTION, which is the amount of power production lost because of a trip or reduction in power. The entity set UNIT/EVENT REACTION has no key attribute of its own. Its identity is determined by the unit number and the event number, and its relationships to UNIT and to EVENT are shown as ID relationships.

Another example of an ID relationship is the use of subset entities, where one entity is a subset of a parent entity. The parent entity contains the key attribute and other common attributes. The subset entity has only those attributes particular to that subset of the larger parent entity set, and it uses the identifier assigned to the parent entity.

4.2.6.4 Entity Subsetting

Entity subsetting is a technique used in the PIN in which one entity is identified as a subset of another entity. This condition is denoted by IS A as the relationship phrase, 1-1 as the cardinality, and ID on the relationship symbol or report column.

Entity subsetting provides the following modeling capabilities:

- Attributes can be modeled at a level of detail beyond that of the parent entity sets.
- Common attributes can be listed at the parent level and do not have to be repeated in each of the subset entity sets.
- Complex and redundant relationships are avoided by linking parent entity sets to one another and by relating the subset entity sets only to their parent entity sets.

In an entity subset relationship, one entity is considered the subset entity and the other the parent entity. For example, MECH/PROCESS EQUIPMENT (700) is a parent of VALVE (301), because all valves are also considered as entries in the MECH/ PROCESS EQUIPMENT entity set.

The following rules apply to entity subsetting:

1) The only relationship to a subset entity is to its parent. The relationship is shown as IS A, 1-1, and ID. Relationships to other entities are made from the parent entity.
2) Only the parent entity has a key attribute. A unique identifier for the subset entity set is not needed because it uses the identifier of the parent.
3) The subset entity has only those attributes that do not generally apply to a significant number of entries in the parent entity set. For example, RELAY (325) is a subset of DEVICE/INSTRUMENT (310). CONTACT RATINGS is an appropriate attribute for RELAY, but LOCATION is an attribute of the parent entity set DEVICE/ INSTRUMENT because all devices and instruments generally have a location.

Table 2 lists of some of the parent and subset entities found in the PIN.

Table 2—Example of Subset Entities From the PIN

Parent Entity		Subset Entity	
064	JOB PERMIT	065	FIRE PROTECTION PERMIT
		066	AREA ACCESS PERMIT
		067	RADIATION WORK PERMIT
310	DEVICE/INSTRUMENT	325	RELAY
		326	METER/RECORDER
		328	STATUS LIGHT
		337	RADIATION MONITOR
451	CIVIL STRUCTURE	452	FOUNDATION
		453	SPILLWAY/DISCHARGE STRUCTURE
		455	SETTLEMENT MONUMENT
		456	DAM
700	MECH/PROCESS EQUIPMENT	135	HVAC DAMPER
		301	VALVE
		753	VALVE OPERATOR
		758	PUMP
		781	PUMP SEAL ASSEMBLY
704	ELECTRICAL EQUIPMENT	750	MOTOR
		751	TRANSFORMER
		752	BREAKER
		754	PANEL/ENCLOSURE
705	CIVIL EQUIPMENT	765	CONVEYOR/FEEDER
		767	BUNKER/HOPPER
		776	HOIST/CRANE

4.2.6.5 Type Entities

Type entities describe groups of items, not individual items. Examples of type entities are CABLE TYPE, EQUIPMENT TYPE, CATALOG ITEM, LOAD TYPE, DEVICE/INSTRUMENT TYPE, PIPE TYPE, and PIPE S/R TYPE. Type entities are used to describe similar components, designs, and loads contained in other entity sets. The other entity sets account for all individual occurrences of the component, design, load, and so forth. A type entity can correspond to an item in the catalog of a manufacturer that may have many real occurrences in the plant, or a typical structure design that may be used at several different locations, or even a description of a load that occurs at several points along a supporting structure.

As an example, an entry in the PIPE S/R TYPE entity set would describe a certain configuration of a piping support/restraint to be used in a plant. The attributes of this entity include its fabrication code, location tolerances, surface coating, selection requirements, and others that simultaneously apply to every support/restraint of this description. Specific attributes of the individual support/restraints are found on the entity PIPE S/R and include location, dimensions, and installation status because these attributes apply to each individual pipe support/restraint in the plant.

Type entity sets are usually identified by the key attribute utility part number (01). Additionally, most type entities have the word type in the name of the entity set.

4.2.6.6 Documents As Entities and As Attributes

Drawing numbers, specification numbers, data sheet numbers, and other reference documentation attribute identifiers are included in the PIN for many entities. However, only major categories of documents have been identified, because the exact details of document contents differ from one organization, plant, unit, or utility to another. For example, the attribute drawing number for the entity COLUMN refers to the primary drawing showing the location and dimension details, but the column is also shown on many other drawings.

Drawing numbers and specification numbers can be thought of as attributes of entities because they help describe the entity. But since these documents themselves have attributes, such as effective date and originator, and since there is a significant relationship between documents and the entities contained in the documents, the documents are better classified as entities.

In addition to the various drawing identifiers included as attributes in the PIN, there is also an entity called DRAWING/SPECIFICATION (098), which can represent any drawing, specification, data sheet, or other document that contains plant information. The relationship between this entity and other plant entities is many-to-many because a component can appear on many documents (e.g., location document, data sheet, dimension details, and procurement specification) and a single document can contain or refer to many components at a time. These exact relationships have to be determined by the implementing utility and are best implemented in a flexible manner so that the data model can be modified easily when document standards and methods change.

4.2.6.7 Attributes of a Relationship (REF ENTITY)

Attributes can sometimes apply to a relationship as well as to entities in the PIN. For example, there is a relationship RECEIPT ITEM IS TRANSFERRED TO STOCK LOCATION used by the material receiving activity (3G09).

This relationship has an attribute of date, which gives the date that the item was sent to the stock location.

Since this relationship approximates an entity, it is assigned a three-digit entity number and is entered into the data list as an entity with attributes. It is also recorded by a relationship between RECEIPT ITEM and STOCK LOCATION. This entity number appears on the activity E-R diagram next to the relationship symbol, and it appears in the activity E-R table and the E-R report under the column labeled REF ENTITY.

4.2.6.8 Scope of the Document/Records Management Activity

There are several differences between the document/records management (4D02) activity documentation package and other activity packages.

The document/records management activity is unique in that it has major interfaces to every other plant activity. Instead of listing all these activities as flowpaths, the activity data list shows an activity name of “ALL” to denote that document/records management sends information to and receives information from all other activities.

Another feature of the document/records management activity package is that the activity was documented with the scope of controlling the storage and distribution of plant documents and records, and the entities and attributes necessary for this control are included in the activity package. The relationship between the documents and the document contents is not shown here, but it is shown in the various activities that work with the document contents. Since the data contents of various plant documents differ from one organization to another, the tasks of actually naming the various documents and relating them to their contents are best performed by the utility during CAE application development.

4.3 Instructions for Using the PIN

This section describes how to find and customize information in the PIN in support of the development of a functional specification for a CAE application. This information has been organized as follows:

1) Finding activity information
2) Finding plant information
3) Customizing the data model
4) Adding/investigating activities

The activity PIN information may be found in the following EPRI Report NP-5159-Ms [1] appendixes:

Appendix C	Activity List Activity Short Descriptions
Appendix D	Activity Documentation Packages —Activity Description —Activity Process Diagram —Activity Data List —Activity Entity-Relationship Diagram and Table —Activity Entity-Relationship Table —Activity Support Modules
Appendix E	Activity Data Lists of Uninvestigated Activities
Appendix F	Data List
Appendix G	Entity Relationships
Appendix H	Data Usage List

4.3.1 Finding Activity Information

This section deals specifically with finding activity information such as the data contents and data interfaces to other activities.

4.3.1.1 Finding Activities

The activity list contains over 400 activities that support a generating plant during its life. To find the activities that may be involved in a proposed CAE application, this list can be scanned for activity names that may be appropriate to the scope of the application. Knowledge of the plant phase and functional area for the activity will aid in narrowing down the list of activities to be considered. If the name of the activity is not sufficient to determine whether or not the activity is relevant to the application, then the activity short descriptions can be referenced for a brief description of the activity. The contents of the activity list and activity short descriptions are described in detail in 4.2.2.

4.3.1.2 Finding Activity Investigation Results

Once the desired activities have been located in the activity list, additional information about each activity may be found in its activity documentation package if it is one of the activities that have been investigated. These activities are identified with an asterisk beside the activity name in the activity list.

The activity documentation package contains a detailed activity description, activity process diagram, activity data list, E-R diagram, and a list of activity support modules. Descriptions of the various parts of this package are given in 4.2.

4.3.1.3 Finding Activity Data Contents

Much of the plant data required to support a CAE application can be found in the data list for the activity in which the application will be used. Two methods are used to find the activity data contents, one for documented activities (i.e., those with activity documentation packages) and another for undocumented activities.

For a documented activity, the activity data contents are located in the activity data list of the activity documentation package. The activity data list, described in detail in 4.2.3.3, contains an input data list and an output and internal data list. The input data list shows the name, number, and description of each data item supplied to the activity. The output and internal data list similarly shows each data item that is kept internally or supplied to other activities. Data items in the activity data list are sorted by their data item number, and data items that are created or updated during the activity are marked with an asterisk in the output and internal data list. Portions of the input and output data lists for the fire protection zones activities (2C10) are shown in Figs 9 and 10, respectively.

For an undocumented activity, a partial activity data list may exist because interfaces to documented activities identified these data items. These lists are only partially complete because these activities were not investigated. In this case, the only data items listed are those identified by other documented activities via data flowpaths to or from this activity. Appendix E of EPRI Report NP-5159-Ms [1] contains these partial activity data lists.

4.3.1.4 Finding Interfacing Activities

For a documented activity, all interfacing activities are identified in the right column. For an undocumented activity, interfaces may be found in Appendix E. In this case, the only activities shown in the right column are those documented activities that have identified data flowpaths to or from this activity.

4.3.1.5 Finding Activity Data Relationships

The relationships between entities of a documented activity are identified in the E-R diagram and table of the activity documentation package. These relationships must be reviewed to determine which ones are required to support the proposed CAE application. They also may be needed for future expansion or interfaces to the application. As described in 4.2.3.4, entity sets are identified by rectangles on the E-R diagram; relationships are identified by diamonds. Fig 12 contains the E-R diagram for activity 2C10, fire protection zones. As an example, the relationships of the entity set FIRE BARRIER in Fig 12 are located by following the lines that connect the FIRE BARRIER entity set to other entity sets. Relationships found in Fig 13 are:

SLAB	ACTS AS A	FIRE BARRIER
WALL	ACTS AS A	FIRE BARRIER
MISC. STRUCTURE	ACTS AS A	FIRE BARRIER
FIRE BARRIER	SEPARATES	FIRE PROTECTION ZONE

The data relationships for an undocumented activity can be determined only through an investigation of the activity. The process for investigating an undocumented activity is presented in 4.3.4.2.

4.3.2 Finding Plant Information

As described earlier, information for specific activities can be found in the activity documentation packages and the activity data lists of uninvestigated activities. However, it may be necessary to examine all plant information, regardless of which activities use it. This could be necessary when a proposed CAE application requires data that spans many activities. This also enables the user to specify flexibility in the CAE application, so that additional activities or data functions may be integrated at a later date with a minimum impact on the application. Instructions for finding information in the PIN for the entire plant are given in 4.3.2.1 through 4.3.2.3.

4.3.2.1 Finding Data Items in the PIN

Appendix F contains the data list of all entities and attributes in the PIN, regardless of which activities use them. The list is sorted by entity number and by attribute number within each entity. The entity number must first be known to find a data item in the list.

Several ways of finding the desired entity numbers in the PIN are as follows:

1) A pair of entity indexes is located at the beginning of the data list. One index lists all entity numbers and names sorted by the entity number, and similar or related entities are generally grouped together. The other index is sorted alphabetically by theentity name, and a known entity name can be quickly located to find its entity number.
2) The activity documentation packages list the major data contents of each activity. If one can determine which activities use the entity that one is trying to locate, one can scan these data lists to locate the desired entity and read its entity number.
3) The E-R report lists all entities related to any given entity. If one finds some entities that are related to the entity one is looking for, this report can help to find the desired entity and read its entity number.

Once the entity number is known, the entity can be found in the data list that is sorted by entity number. The attributes of the entity are listed following the entity name. A sample page from this data list is shown in Fig 16. This list of attributes may not contain all the ones that are appropriate for this entity. Additional attributes might be on a related entity set, depending on the type of relationship between the two entity sets. The attributes of the other entity sets should also be reviewed to determine their applicability to the proposed CAE application. Two examples of these additional attributes are described below:

— Relationships with a one-to-one (1-1) cardinality and an ID dependency usually imply that one entity set is a subset of the other. This type of relationship, which is explained in 4.2.6.4, places general attributes on the parent entity (such as LOCATION for the DEVICE/INSTRUMENT entity) and places subset-specific attributes on the subset entity (such as LENS COLOR of the INDICATING LIGHT entity). Thus, to find all attributes of INDICATING LIGHT, one would also have to examine the attributes of its parent entity DEVICE/INSTRUMENT to see if any additional attributes are appropriate for the intended CAE application.
— Some relationships with a one-to-many (1-M) cardinality represent one entity describing several occurrences of another entity, such as
  ELECTRICAL EQUIPMENT IS DESCRIBED BY EQUIPMENT TYPE (M-1)
  In this example, the ELECTRICAL EQUIPMENT entity contains the attributes related to the specific usage of an individual piece of equipment (such as LOCATION, OPERATING STATUS, and CONDITION). Additional characteristics about the equipment may be found on the EQUIPMENT TYPE entity, which contains those attributes that are common to all locations and usage of the identical pieces of equipment (such as ESTIMATED COST, INDUSTRY EXPERIENCES, and DESIGN CODE). Thus, to find all attributes of ELECTRICAL EQUIPMENT, one should also examine the entity EQUIPMENT TYPE to see if additional attributes are appropriate for the intended CAE application.

4.3.2.2 Finding Relationships to an Entity Set

The E-R report contains the list of all relationships between any pair of related entity sets in the plant data model.

The report is sorted by entity number. To find all relationships to a given entity set, the report is searched by entity number to find the desired entity set. All relationships are listed below the entity name. (A relationship may be listed more than once since it is listed for each entity that uses it.)

The same procedure is used to find a specific relationship. However, since the report lists the relationship under each of the related entity sets, either entity number may be used to find the relationship.

As an example, Fig 17 contains a portion of the E-R report for the RADIATION ZONES entity set.

4.3.2.3 Finding Activities That Use a Data Item

All activities that use a specific data item can be found from the data usage list. This is useful in determining all the potentialuses of the data item. These activities should be considered for integration benefits when specifying the application.

The data usage list is sorted by data item number and lists all of the flowpaths for each data item. From these flowpaths, a list of activities that use the data item can be derived. To find the list of flowpaths for a specific data item, simply search through the report for the number of the data item. The flowpaths are listed below the data item. As an example, Table 3 contains a portion of the data usage list for the data item CABLE ESTIMATED LENGTH.

4.3.3 Customizing the Data Model

After identifying the activities and data that are applicable to the CAE application, the data model may have to be customized, either to aid in the development of the CAE application or to suit the needs of the user. This may entail adding new attributes, splitting existing attributes, adding entities, or expanding relationships.

Table 3—Activities Using Data Item CABLE ESTIMATED LENGTH (Data Usage List)

100-21	CABLE	ESTIMATED LENGTH
2E01—AUX SYS CONFIG/LAYOUT	TO	2E20—CABLE SYSTEM DESIGN
2E20—CABLE SYSTEM DESIGN	TO	2E21—CABLE ROUTING
2E21—CABLE ROUTING	TO	2P03—PARTS/EQUIP ORDERING
2E21—CABLE ROUTING	TO	3D06—CABLE PULLING

When customizing the data model to suit the needs of the user, it is very important to maintain a cross-reference between the PIN and the new customized data. This cross-reference is valuable when adding future CAE applications and in communicating with architects or engineers, vendors, manufacturers, utility organizations (e.g., EPRI, INPO), and other companies. The conventions used in the PIN for numbering activities, entities, and attributes are described in 4.2. Numbering conventions for customized data must also be maintained, which correlate the numbers assigned to the customized data to the original PIN data items.

4.3.3.1 Adding New Attributes

As part of customization, new attributes may have to be added to an entity set. For example, additional information may be needed for the entity PIPE S/R (331), such as the date the pipe support/restraint was last inspected. This attribute can be added to the data model by assigning a new attribute number and name. In order to distinguish customized attributes from those in the original PIN easily, two letters can be used in place of the two digits usually found in the attribute number. The example in Table 4 shows the new data item PIPE S/R—DATE LAST INSPECTED (331-AA) along with some existing attributes of PIPE S/R.

After determining a proper definition for the new attribute, it can then be merged into the PIN data list and used in defining additional data flowpaths between activities.

4.3.3.2 Splitting an Attribute

The CAE application may require splitting existing attributes to achieve a finer level of detail. This can be performed by expanding existing attribute numbers. For example, the entity PIPE S/R has an attribute LOCATION with the data item number 02. For the requirements of the application, the attribute LOCATION may be too general and may require a more detailed definition to include the building in which the pipe support/restraint is located, the floor elevation of the room, and the nearest column line to the pipe support/restraint.

Table 4—Entity Attributes After Customization

Entity	Attributes
331—PIPE S/R	01—IDENTIFIER
	02—LOCATION
	03—DIMENSIONS
	04—DESCRIPTION
	06—NUCLEAR SAFETY CLASS
	AA—DATE LAST INSPECTED

New attribute numbers such as 02AA, 02AB, and 02AC could be used to link these new attributes to the original PIN attribute LOCATION (number 02). Table 5 shows the same example as is shown in Table 4, with LOCATION replaced by the three expanded attributes.

Table 5—Splitting the Attribute LOCATION

Entity	Attributes
331—PIPE S/R	01—IDENTIFIER
	02AA—BUILDING
	02AB—ELEVATION
	02AC—COLUMN LINE
	03—DIMENSIONS
	04—DESCRIPTION
	06—NUCLEAR SAFETY CLASS
	AA—DATE LAST INSPECTED

The attributes 02AA—BUILDING, 02AB—ELEVATION, and 02AC—COLUMN LINE can be easily recognized as customized information related to the original PIN attribute 02—LOCATION.

4.3.3.3 Adding and Relating Entity Sets

The entities in the PIN can be easily related to customized entity sets. This can be done by assigning entity numbers to the customized entity sets and then defining relationships between these entity sets and the PIN entity sets.

For example, a utility is using an EMPLOYEE TASK entity set to keep track of tasks assigned to individual employees. Some of these tasks relate to certain pipe support/restraints. Consequently, the utility may wish to relate its entity set to the PIN entity set PIPE S/R. Since the PIN currently has no entity set that corresponds to the concept of EMPLOYEE TASK, the utility adds it to the PIN by assigning it the entity number AAA. The PIN currently contains numeric entity numbers; therefore, the new entity is easily distinguished from original ones. Similarly, the utility adds PROJECT to the PIN by assigning it AAB. These utility-specific entities, along with their attributes, can now be merged into the PIN data list.

The last step is to define relationships between the customized entity sets and the existing PIN entity sets and to merge these relationships into the PIN activity documentation package(s) and/or PIN E-R report. Entity relationships are described in detail in 4.2.3.4 and again in 4.2.6 for special types of relationships. Table 6 shows new relationships defined for utility-specific entities as they would be merged into the PIN.

Table 6—New Relationships for an Entity

Relationship			
Entity	**Phrase**	**Entity**	**Cardinality**
331 PIPE S/R	IS ANALYZED BY	AAA EMPLOYEE TASK	M-1
AAA EMPLOYEE TASK	SUPPORTS	AAB PROJECT	M-1

4.3.3.4 Expanding a Relationship

Many times a relationship between two entities behaves like an entity itself in that the relationship has attributes associated with it. Expanding a relationship means assigning it an entity number so that its attributes can be assigned, or in the extreme case, converting it to an entity to relate it to additional entities.

This technique is more fully explained in 4.2.6.7. For example, the entity CABLE is related to the entity ELECTRICAL EQUIPMENT by the relationship IS CONNECTED TO. The attribute STATUS may be needed on that relationship to describe the status of the connection between the cable and the electrical equipment. Similarly, the attributes DATE OF CABLE CONNECTION, DATE OF CABLE CONNECTION INSPECTION, and DATE OF CABLE CONNECTION SEALING may be needed on the relationship IS CONNECTED TO.

To add attributes to a relationship, the relationship must be assigned an entity number and an appropriate entity name so that it can be added to the PIN data list along with its newly defined attributes. REF ENTITY number is shown on an E-R diagram and in the PIN reports, as described in 4.2.6.7. Using this technique, the relationship remains intact with the following additions:

1) A new REF ENTITY number is assigned to the relationship.
2) The REF ENTITY number is added to the E-R diagram(s) just outside the relationship symbol.
3) The REF ENTITY number is filled in on the tabular versions of the PIN entity relationships.
4) An entity name is made up to describe the relationship.
5) The REF ENTITY number and name are entered in the PIN data list as a new entity.
6) The new attributes are added to the E-R diagram(s) with a line connecting each attribute to the relationship symbol.
7) The new attributes are assigned numbers and definitions and are entered in the PIN data list.

Sometimes a relationship must be converted to an entity set. This can occur if the relationship evolves to a point where it essentially represents a stand-alone entity set that requires relationships to other entity sets. Since the PIN modeling techniques do not allow a relationship to be related to an entity, the relationship must be first converted to an entity. This new entity is then related to the two original entities and is now able to be related to any other entities as needed.

The example CABLE IS CONNECTED TO ELECTRICAL EQUIPMENT will be used to demonstrate converting a relationship to an entity as follows:

— Determine an appropriate entity name to describe the relationship, such as CABLE/EQUIP CONNECTION, if one has not yet been assigned.
— Assign an organization-specific entity number to the new entity, such as AAC, if not already assigned. Add this entity to the PIN data list.
— Assign attribute names, definitions, and numbers if not already defined. Add these attributes to the PIN data list.
— On the E-R diagram(s), replace the relationship with the new entity. Define two new relationships to relate the new entity to the two original entities. For example, CABLE/EQUIP CONNECTION “TERMINATES” CABLE, and CABLE/EQUIP CONNECTION “IS AT” ELECTRICAL EQUIPMENT. Define the appropriate cardinality for each relationship.
— In the E-R table(s) and the PIN E-R report, replace the original relationship with the new relationships.
— Add any new relationships needed to the new entity, such as CABLE/EQUIP CONNECTION IS AT MECH/PROCESS EQUIPMENT, on the E-R diagram(s) and in the E-R tables and report.

4.3.3.5 Customizing Document Information in the PIN

Drawings, specifications, and other reference documents are shown in the PIN in a variety of ways. For example, DRAWING NUMBER is listed as an attribute of many entities, such as CABLE TRAY HANGER. Also in the PIN is an entity called DRAWING/SPECIFICATION (098) that shows relationships to many of the other PIN entities. The use of these two ideas in the PIN is described in 4.2.6.6.

Additionally, the document/records management activity (4D02) uses an entity called document/record (250) as the starting point for receiving, storing, and transmitting copies of plant records. Each utility should decide upon its own important documents and relate them to the appropriate entities in order to cross-reference documents to the major data contained on those documents.

During customization of data, documents can be used as attributes of entity sets. If more detailed information about documents is required by the application, then documents would be better implemented as a separate entity set. In the case where a separate entity set is used, the entity set must have an entity number and be related to the appropriate entity sets in the PIN.

4.3.4 Adding/Investigating Activities

New activities may need to be added or existing activities investigated further when developing a CAE application functional specification. Some of the reasons for adding or investigating activities are

1) Plant-Specific Activities: Activities that are unique to a specific utility or plant may not already be a part of the PIN.
2) Uninvestigated Activities: The application of the user may involve activities that are part of the PIN but not among the documented activities.
3) New Industry Activities: New activities may arise from changes in industry technology, processes, or requirements. These activities may have to be investigated, documented, and merged into the PIN to enable these activities to interact with other PIN activities.
4) Greater Level of Detail Needed: Information in the PIN has been documented on a general level to ensure applicability to most organizations. To expand these data items into the greater level of detail needed to

implement the CAE application, the activities involved may need additional investigation and incorporation into the PIN.

4.3.4.1 Defining a New Activity

Defining a new activity involves naming, scoping, and numbering the activity according to conventions used for previous PIN activities.

1) The name of the activity should be chosen so that its scope can be differentiated from the scopes of other activities.
2) The activity scope should be defined to minimize overlap with other activities in the PIN. A short activity description should be added to the activity list.
3) The activity should be assigned an activity number according to the hierarchy of phase, functional area, and activity in a similar manner to the existing activities. However, to differentiate the new activities from existing PIN activities easily, it is suggested that alphabetic characters be used; for example, “AA” in place of the two digits found at the end of a PIN activity number. For example, “2C14” represents the PIN activity tank design, while “2CAA” could represent a new activity defined by an organization.

4.3.4.2 Investigating New Activities

The objective of a new activity investigation is to determine the scope, major tasks, data contents, and activity interfaces of the activity. The investigation results are documented in an activity documentation package, as described in 4.2.3.

Investigating an activity and documenting its information needs is a process that requires expertise in both the activity being investigated and in the data modeling methods used in the PIN. The investigation process should include a review of existing manuals, procedures, specifications, regulations, computer programs, and other documents or guidelines either used by or produced by the activity. Procedures are usually helpful in scoping the activity and documenting the major tasks performed. Documents and computer programs usually contain most of the data, in one form or another, used by or sent out from the activity being investigated.

An example procedure for investigating activities is given below. This method for investigating activities lends itself to using forms that resemble the final sections of the activity documentation package. However, each utility should establish a methodology for investigating new activities that best suits its needs and organization.

1) Define the scope and boundaries of the activity and develop the activity description. Keep in mind the scopes of related or interfacing activities by reviewing their short descriptions and their activity documentation packages. Make corrections or clarifications to existing activity scopes or to the new activity scope if needed to define the boundaries between activities more clearly.
2) Determine the major tasks performed in the activity, and develop the activity process diagram showing the general sequence of the major tasks. Also, show the tasks being performed without regard to whether the utility, contractor, computer program, or other function is performing the tasks. In this way, the activity process diagram will remain valid even with minor changes in procedures, methods, or computerization.
3) List all the input documents that are received from other activities and are required to perform this activity. Also, list all the output documents that are used to record activity information and/or to send out information from this activity to other activities. In this context, document refers to any drawings, reports, manuals, catalogs, computer screens, data bases, or any other means of receiving, recording, or sending out activity information. These are informal lists that are used when developing the activity data list.
4) Review any partial or complete activity data list that may already exist for this activity. This step is only appropriate if the activity is already part of the PIN rather than a new activity being defined. Use this list as a starting point in identifying the major data items associated with this activity.
5) Determine all the major input data items that are used by the activity by reviewing in detail each input document listed. List these data items in an entity-attribute format as described in 4.2.3.3, referring to the PIN data list to follow the naming conventions of data items that have already been defined by other activities. List

only those data items that appear on the document and are needed to perform the activity being investigated. Then describe each data item and list the activities from which each data item is received. One may need to refer to the activity list, which contains short descriptions of all the PIN activities, to help identify the proper sources of each input data item. This list becomes the input data portion of the activity data list.

6) Determine all the major output and internal data items that the activity records for its own use, sends out to other activities, or simply passes along to other activities along with related data. This is done mainly by reviewing in detail each output document listed. Again, provide a description for each data item and list the activities to which each data item is sent. For data items created or recorded by this activity but not sent out to any other activities, list this internal data with the output data, but show the data as being sent out from the activity to itself. As an example, data item 405-13 in Fig 10 is internal data for the fire protection zones activity. This internal data technique is used to record a flowpath for a data item that would not otherwise have a flowpath, since this data item is not used in an interface to any other activity. Show an asterisk beside the attribute name in this output and internal data list if the values of the attribute can be created or updated by the activity. This helps identify activities that need the capability to update certain data items when developing a CAE application functional specification. These two types of data, internal and output data, are shown together to form the output and internal data portion of the activity data list.
7) Develop the activity data model for the data items identified. Develop the E-R diagram and/or table of the activity, whichever is more convenient to use, according to the definitions in 4.2.3.4. However, if the diagram form is used, it will be necessary to convert it to a table to merge the relationships into the PIN. This conversion process is explained in 4.2.3.4. Assign new data item numbers, where applicable, as described earlier. Refer to the E-R report in order to use relationship phrases that may have already been identified by other activities. If a new relationship phrase is needed, make up a phrase that describes the relationship when read from the lower entity number to the higher entity number, as explained in 4.2.3.4.
8) List any support modules as appropriate to help scope the activity, to describe constraints on the data contents or data handling, and to list potential computer programs that could assist in the handling of the data of this activity.
9) Integrate the data definitions, activity data flowpaths, and entity relationships with the rest of the PIN by following the appropriate activity and data naming and numbering conventions.

The end result of the activity investigation process should be a completed activity documentation package and modifications to the PIN from merging in new activities, new data, new data relationships, and new data flowpaths.

4.3.4.3 Investigating Existing PIN Activities

The preceding process can also be used when investigating an existing PIN activity as needed to define its data contents further or to adjust its scope. In this case, the PIN may already contain significant information about the activity that would help as a starting point for the investigation.

Each of the over 400 activities identified in the PIN contains at least a short description in the activity list. These short descriptions help to scope each activity and to identify the boundaries between activities.

4.4 CAE Application Development and Integration

This section presents a series of issues that must be addressed when integrated CAE applications are designed and implemented. It also makes specific recommendations about bow to handle these integration issues. The issues fall into three general categories:

- Data issues
- System and interface issues
- Organizational issues

4.4.1 Data Issues

There are a number of concerns that must be addressed by the CAE designer that relate solely to the data. Some of these are discussed in 4.4.1.1 through 4.4.1.8.

4.4.1.1 Data Duplication

The storing of redundant data should be avoided if at all possible. However, application performance considerations and hardware/software limitations may necessitate maintaining duplicate data items in multiple locations. If data duplication is necessary, then the issue of data integrity should be addressed. CAE applications with duplicate data items should be designed to maintain data integrity by consistently updating the duplicate items at each location. The problem of updating multiple locations of the same data item must be considered by the CAE application designer.

4.4.1.2 Data Security

Data security is an important consideration in any data base. As data use is increasingly integrated, security issues become increasingly critical.

4.4.1.3 Data Integrity

Data integrity is defined as the implementation of controls and safeguard mechanisms that guarantee that changes made to the data-base design do not jeopardize the integrity of the data. Alternatively, this ensures that the information stored is correct for every user.

4.4.1.4 Data-Base Management Systems (DBMS)

Data-base management systems (DBMS) are used to store and access data on demand. Features common to DBMS are data manipulation for update and retrieval, concurrent access by multiple users, and recovery from system or media failures.

Some of the types of DBMS in use are hierarchical, network, inverted list, relational, and object-oriented. Each type of data-base system offers different advantages, and selection of a system must be made with care.

4.4.1.5 Distributed Data Bases

A distributed data base makes use of physical data storage on two or more computer systems. Proper functioning of distributed data bases may be maintained by a distributed DBMS or by application software. The complexity of managing a distributed data base is greatly increased when not using a distributed DBMS because of requirements for synchronizing data-base updates and recovery across multiple locations.

The CAE application program logic must maintain the distributed data base. Therefore, without the use of a distributed data-base manager, the complexity of an application increases because of problems such as synchronizing data-base updates and data duplication.

4.4.1.6 Data Transportability

To allow users to transfer data across a variety of hardware and software, developers should be sure to retain flexibility in selecting hardware and software applications. Awareness of technical considerations, when properly addressed, accommodate the transfer of data through the life cycle of a plant.

4.4.1.7 Change Control

The integration of peripheral applications into the PIN database will result in the exchange of data into and out of the data base. To prevent the unwanted updating and potential corruption of the data base, a method of effecting change control must be used. Ideally, this change-control mechanism will serve as an engineering data environment manager, allowing for the management of data by user-defined parameters, such as by project, program, or other grouping requirements. More importantly, establishing a sign-off and release mechanism for managing the data cycle is another requirement of the selected environment manager.

4.4.1.8 User Training on Information Engineering Principles

To aid in the successful implementation of a PIN-based CAE system, it is recommended that the user community be trained in the fundamentals of information engineering. This will provide the end users with the knowledge needed to utilize the PIN more fully.

4.4.2 System and Interface Issues

Interfaces for the user and other applications should be well thought out and planned in advance for consistency. Some considerations are given in the following subsections.

4.4.2.1 Design of the User Interface

The most important interface in any CAE application is the interface to the user. User-friendly interfaces are especially important in interactive programs, and a consistent user interface across a large number of applications provides an integrated appearance to the user. The elements of a well-designed user interface are as follows:

1) Menu-driven interfaces
2) Consistent syntax for commands
3) Allowance for the user to enter values in a units system familiar to the user
4) Inclusion of an on-line help facility in the program
5) Use of error messages that the user will understand
6) Use of color to enhance displays
7) Use of the same user-interface standards across many application programs

4.4.2.2 CAE Application Interfaces

Providing an environment for application programmers to write PIN interfaces over a broad base of users will increase the level of acceptance of the PIN methodology both by users and developers.

The plethora of currently available CAE applications that support the design, construction, and operation of power plants must be accommodated in any PIN implementation. To do this effectively will require the development of application interfaces to retrieve the required data from the data base and correspondingly put back the resulting data. To avoid the high cost of developing custom interfaces repeatedly for applications, application developers should be provided with the capability to write an interface for their software that will work with any PIN implementation. To do this will require low-level data-base access routines as a requirement for the selection of a data-base application (see data-base transportability). In addition to low-level access routines, attribute naming to facilitate the retrieval and replacement of data in a controlled fashion should be standardized. Without the ability to write standard interfaces, the cost of a successful PIN-based CAE system will increase drastically. Providing an environment for application programmers to write PIN interfaces for a broad base of PIN users will increase the level of acceptance of the PIN methodology both by users and developers.

4.4.2.3 Data-Base Administration

Often, in a corporate data-base environment, an individual or central group is responsible for the design and maintenance of the corporate data model. This data-base administration function provides an organization to maintain and use the data model effectively.

During the plant data model customization phase, it is important to develop the data model around the core data entities in the application. There are usually a few such entities that stand out, since they relate to most of the other data items in the application. These core data entities should be developed and customized first. The application is easier to design and implement when this approach is used, since a focal point in the data base has been identified early in the design stage.

5. Development of a Functional Specification Based on the PIN

5.1 Using the PIN in the Development of a CAE Functional Specification

A functional specification is an essential element in the development of CAE software. Such a specification will contain parts that can be derived largely from the PIN. The following outline presents one example of the steps that should be addressed in developing those parts of a functional specification that relate to the PIN:

Step 1—Define the scope of the CAE application.
Step 2—Identify relevant PIN activities.
Step 3—Initiate development of the application data model.
Step 4—Identify related activities.
Step 5—Revise the scope of the application.
Step 6—Economic analysis.
Step 7—Customize the application data model.
Step 8—Describe the detailed functional requirements.

5.1.1 CAE Application-Specification Procedure

The following procedure describes the steps listed in 5.1. Appendix A of this recommended practice contains an example illustrating these instructions.

5.1.1.1 Step 1: Define the Scope of the CAE Application

Provide a clear description of the problem to be solved, state the objectives of the application, identify the organizations involved, and clarify what is to be included in, or excluded from, the application. The definition of the problem and scope should be descriptive enough to indicate the primary activities affected and the types of data needed.

5.1.1.2 Step 2: Identify Relevant PIN Activities

Determine the primary PIN activities for which the application is to be used from the application scope defined in Step 1. This can be accomplished by first identifying the phase and functional area of the plant life cycle where the application will be applied. Then, using the activity list, the applicable activities can be determined from those listed for the specified phase and functional area. The selected activities should be those whose functions will be given direct support by the proposed application. Activities that only provide input data or receive output data are not primary activities supported by this application.

5.1.1.3 Step 3: Initiate Development of the Application Data Model

Examine the respective activity documentation packages for the primary activities and identify the data items (i.e., entities and attributes) that are pertinent to the proposed application. In addition to the data items, the relationships between the entities are also important in producing a comprehensive data model for the application. The subset of necessary data items and relationships should be extracted from the activity data lists and E-R tables. These represent the major data items and data relationships for the application.

Other data items in the PIN may also be required for the application. These can be determined by referring to the data list and by considering all other attributes of the entity sets that were extracted from the data lists of the primary activities. In addition, the index of entity sets listed in the front of Appendix F can be reviewed for any other entity sets that may be pertinent to the application. Their attributes can also be selected from the data list. Finally, the E-R report can be used to determine other relevant entity relationships.

The data requirements determined during this step should be documented in an entity/attribute list and E-R table for the application. An E-R diagram can be useful also. All entities and attributes should be identified by their PIN numbers to facilitate continuity with subsequent applications. The result of this step is an initial application data model derived chiefly from the PIN. Customization of this data model for utility and plant-specific data will be accomplished in Step 7 after the economic analysis has been completed.

5.1.1.4 Step 4: Identify Related Activities

Examine the data flowpaths for the primary activities and their selected data items to integrate the new application fully with interrelated activities. Some of these activities receive output from the primary activities and benefit from use of that data. Other activities that are identified in the flowpaths provide required data to the primary activities. By examining the flowpaths of each data item that is required or produced by the application, all activities that either provide required data to the application or benefit from the production of data can be identified.

The data usage list can be used to follow the flowpath for each data item that the proposed CAE application will use. The goal is to identify any additional activities that should be included in the scope of the application. The intent of this step is not to include every interfacing activity in the application. However, related activities that are already automated should be identified so that a consistent interface can be established for passing data. In addition, activities that supply a significant amount of data to the application should be considered for automation if there is a benefit to receiving the data by automated means.

5.1.1.5 Step 5: Revise the Scope of the Application

Re-evaluate the original definition and scope of the application in light of the activities and data-model components that have been identified in Steps 2 through 4. As receiving activities are identified through the data flowpaths, it may become apparent that a particular activity could benefit significantly from data provided by the application. However, a few additional functions or data items may be needed to accomplish the desired data integration. Also, the proposed application may require input data to be supplied electronically from another activity. This can require adjustments to the scope of the application to make this effort cost-effective for the supplying activity. These kinds of enhancements should be taken into consideration when revising the scope of the application.

5.1.1.6 Step 6: Perform an Economic Analysis

Justify the cost of developing the CAE application based on the savings or additional revenues derived from using the application. This step is common to the development of CAE applications in many organizations. Standard, industry-approved methods for the justification of a proposed application may be used.

When performing an economic analysis for a proposed CAE application, the benefits of data integration across multiple activities should be taken into consideration. These benefits are typically not addressed by the more common methods for cost/benefit analysis. Two methods for approaching the economic benefits of data integration are provided in Section 6 of EPRI Report NP-5159-Ms [1].

5.1.1.7 Step 7: Customize the Application Data Model

The application data model derived from the PIN in Step 3 should be customized to form a detailed data model for the application by

1) The addition of company- or plant-specific entity sets and attributes that are not generic to the industry
2) The addition of new relationships between existing or new entity sets
3) The division of some attributes into multiple data items to provide a more detailed definition of the information

Interviews with prospective users and examination of existing procedures, source documents, and reports can be useful for identifying additional data items. The output of this step is a customized application data model in the form of an entity/attribute list and an E-R table showing all entities, attributes, and relationships that are required to support the application. The technical details of customization are discussed in 4.3.3.

5.1.1.8 Step 8: Describe the Detailed Functional Requirements

Provide a definition of the characteristics of each data item to ensure its proper storage and maintenance and a clear description of how the necessary data are to be manipulated within the application. These characteristics of the data items should include the following:

1) Type (alphanumeric, numeric, date)
2) Length (number of characters)
3) Numeric precision (applies only to numeric fields)
4) Editing requirements (ranges of valid values)
5) Aliases or common names

The functions of the application should be described in detail, making reference to entity and attribute names or numbers in the data model of the application whenever data are required. This approach to describing the functions of the application makes use of the data model to define the interaction of data items in several different entity sets. The logical progression from one data item to another through the relationships identified in the data model is described, beginning with the conditions for initiating the function. The functions should also be associated with the appropriate on-line screens, reports, and input/output files.

5.1.2 Completion of the Functional Specification

Once the activity documentation packages and the PIN data model have been utilized to describe the CAE application, the functional specification can be written. This section identifies the parts of a functional specification that are partially or fully supplied by the procedure just described. Although many organizations have adapted their own functional specification format from publicly available sources such as the IEEE and EPRI, the headings below should clearly indicate the parts of the specification affected, regardless of the format used.

5.1.2.1 Data Requirements

The data requirements of the application are the aspect of a functional specification most affected by the CAE application specification procedure. Data requirements are usually represented in several parts of the functional specification document. Those parts include descriptions of program inputs, outputs, and data-base characteristics.

The entity/attribute list and E-R table produced in Step 7 should be included in the functional specification. The E-R diagram mentioned in Step 3 should be considered also. Entity/attribute definitions can be developed from the data item definitions developed in Step 8. Descriptions of the inputs, the outputs, and the data base can include these items or be cross-referenced to them.

5.1.2.2 Functions

The functions part of the functional specification details the processing requirements for the CAE application. It describes exactly what the CAE application should do in terms of collecting, processing, and reporting data. The results of Step 8 can be used to help describe the data-processing requirements of the application.

5.1.2.3 Scope

The scope primarily defines what is to be included in, and excluded from, the application. It may be developed directly from the products of Steps 1 through 5.

5.1.2.4 Objectives

The objectives of the CAE application are to be stated in such a way as to describe the problems to be solved and to identify the services to be provided. This part of the functional specification can be derived, in part, from the work done for Steps 1 through 5. An examination of the activity documentation packages for the activities within the scope of the application may be useful.

5.1.2.5 References

It is important to include in the functional specification cross-references to the relevant PIN activity, entity, and attribute numbers. This will facilitate data integration by using a single, common data model as the basis for all application data models.

5.1.3 Summary

A functional specification is a formal document that describes the requirements of a new CAE application. A number of the sections contained in the functional specification, particularly those concerning data requirements, can be derived mainly from information contained in the PIN. Using the PIN as a common data model for all functional specifications helps ensure that individual CAE applications are developed in an integrated fashion.

The development of a functional specification should be undertaken jointly by users and information analysts. The users provide the necessary knowledge of the information and the processing requirements of the application. Information analysts furnish an equally important understanding of data analysis, system design, and software development.

Once the functional specification has been completed and approved, the detailed system design process can begin. An important part of the application development process is the design of the physical data base. The entity/attribute list, E-R table, and entity/attribute definitions of the functional specification should provide the basis for the data-base design.

NOTE — A user's group called the "EPRI PIN Users Group" was established to provide a forum for information on implementation and utilization of the PIN. Users of this standard are encouraged to contact the liaison between the user's group and the IEEE regarding participation in this group.

This liaison will be maintained through the Power Generation Committee, Station Design Subcommittee Chair. The user's group will provide recommendations to the Station Design Subcommittee related to modifications of this recommended practice as warranted by changes in technology and knowledge gained from the use of this recommended practice.

Annex A An Example of CAE Application Specification Procedure (Informative)

(This appendix is not a part of IEEE Std 1150–1991, IEEE Trial-Use Recommended Practice for Integrating Power Plant Computer-Aided Engineering (CAE) Applications, but is included for information only.)

A.1 Introduction

This example illustrates the instructions given in the CAE application specification procedure of 5.1.1. The steps of the example correspond to those of the specification procedure. The example addresses the need to identify the control and monitoring devices associated with a motor that is being taken out of service for corrective maintenance. The consequences of removing a motor from service is an important consideration.

A.2 Step 1: Define the Scope of the CAE Application

Corrective maintenance is scheduled for a motor-operated valve. The maintenance requires that the motor be taken out of service while the plant continues to operate. The power supply to the motor must be located and disconnected, and all control and monitoring devices for the motor must be identified. Control devices are to be locked out and, along with the monitoring devices, tagged to prevent accidental usage during maintenance. These devices can be determined by tracing the wiring connections from the terminals on the motor back through the terminal cabinets, motor control centers, interconnection cabinets, and eventually to the control boards. Each device identified during this process can be listed along with its location, function, associated drawings, catalog number, and classification. Other pertinent information, such as circuit and system function, can also be recorded and used to determine appropriate measures that are required when taking the circuit out of service.

The primary objectives for an application that supports this process are

1) Determine the name/number and location of the motor-control-center compartment that provides power to the motor and the control circuit.
2) Determine the name/number, location (within electrical cabinet), function, drawing number, and general classification of all devices in the control circuit. Devices whose general classification is categorized as control (a push-button or switch) or monitoring (an indicating light or meter) are to be listed on a report so that these devices can be tagged and taken out of service.
3) Determine the name/number, type, location, and function of all electrical cabinets in or upon which each of the previous control devices is located.
4) Determine the circuit and system names/numbers and functions that are required for determining appropriate measures when taking the circuit out of service. These can also be used to aid in the identification of interlock devices to other systems or components that must be considered when taking the circuit out of service.

A.3 Step 2: Identify Relevant PIN Activities

The activity list is scanned for activities that address maintenance and include electrical control device/instruments. Most maintenance activities are in the operations phase (Phase 4) of the plant life cycle. Within the operations phase is the functional area I&C/Electrical Maintenance/Engineering (4N). The first three activities (4N01, 4N02, and 4N03) in this functional area are concerned with maintenance to general electrical instrumentation; the others (4N04 through 4N13) address specific systems or major equipment types.

For this example, we will consider both 4N01 (Corrective Maintenance—Instrumentation and Electrical) and 4N02 (Preventive Maintenance—Instrumentation and Electrical), since both activities are concerned with the electrical instrumentation of a circuit, and the size of the motor is less than 200 hp. Other activities, particularly in this same functional area, stand to benefit from such an application, but they are not listed here primarily because their overall data requirements are quite different from those identified for this application. These activities may be included later when data flows are analyzed.

A.4 Step 3: Initiate Development of the Application Data Model

The data model required to support this application was extracted from the activity data lists and E-R tables for activities 4N01 and 4N02 and from the data list. The model is shown in Tables A-1 and A-2. Fig A-1 is an E-R diagram for the application. The entities MOTOR and PANEL/ENCLOSURE appear in Table A-2 and Fig A-1 but not in Table A-1 because the only attributes for MOTOR and PANEL/ENCLOSURE needed for the application can be obtained from the ELECTRICAL EQUIPMENT entity.

Table A-1—Entity/Attribute List for a Motor Control Circuit Tracing Application (Before Customization)

106	CIRCUIT WIRE
01	IDENTIFIER
310	DEVICE/INSTRUMENT
01	IDENTIFIER
02	LOCATION
05	FUNCTION
10	DRAWING NUMBER
313	DEVICE/INSTRUMENT TYPE
01	UTILITY PART NUMBER
27	GENERAL CLASSIFICATION
323	DEVICE TERMINAL
01	IDENTIFIER
352	ELECTRICAL CIRCUIT
01	IDENTIFIER
05	FUNCTION
353	BUS COMPARTMENT
01	IDENTIFIER
701	SYSTEM
01	IDENTIFIER
05	FUNCTION
704	ELECTRICAL EQUIPMENT
01	IDENTIFIER
02	LOCATION
05	FUNCTION
07	TYPE

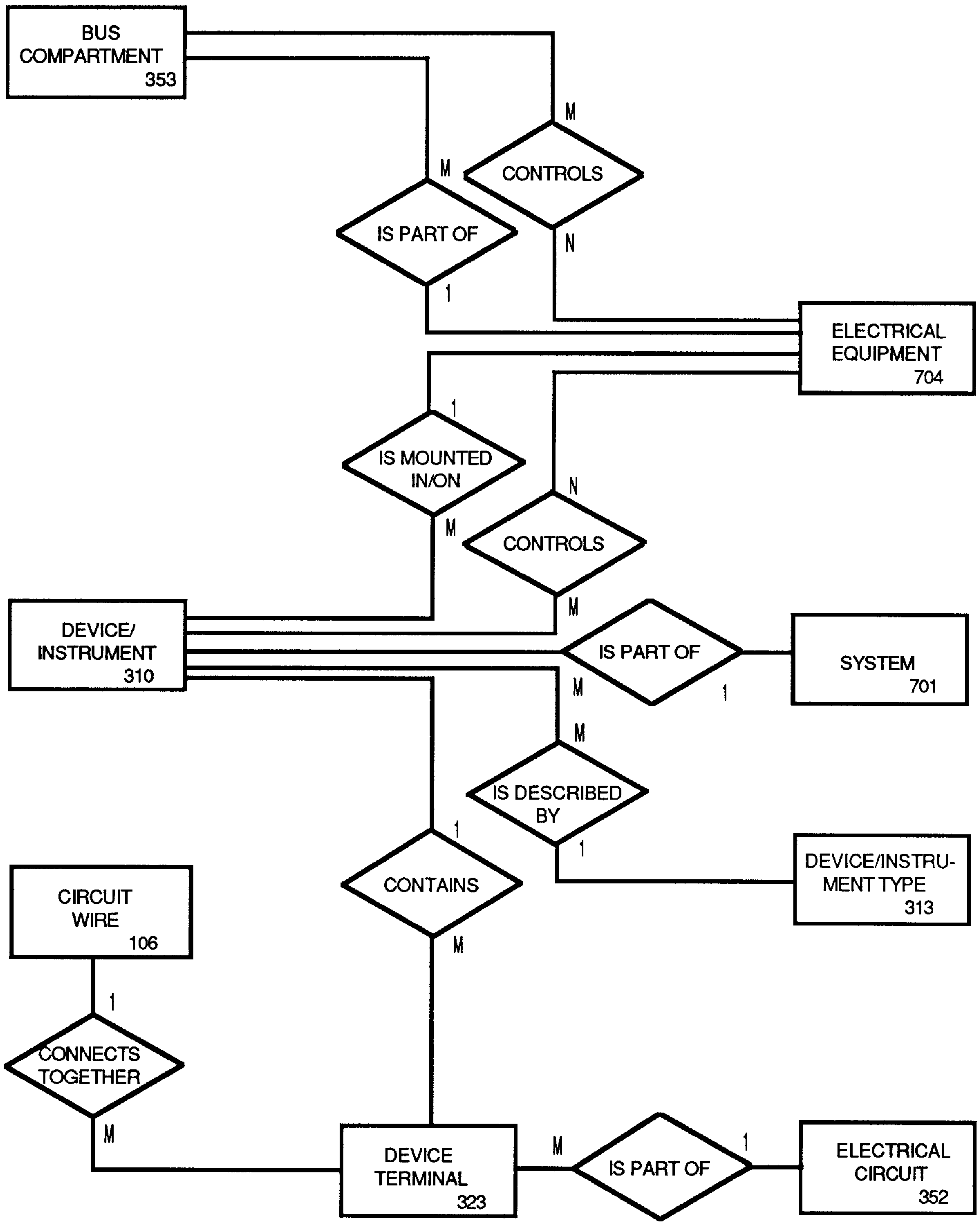

Figure A-1—E-R Diagram for an Example Application

Table A-2—Entity/Attribute Table for a Motor Control Circuit Tracing Application

Entity	Relationship	Entity	Card
106 CIRCUIT/WIRE	CONNECTS TOGETHER	323 DEVICE TERMINAL	1-M
310 DEVICE/INSTRUMENT	IS DESCRIBED BY	DEVICE/INSTRUMENT TYPE	M-1
310 DEVICE/INSTRUMENT	CONTAINS	323 DEVICE TERMINAL	1-M
310 DEVICE/INSTRUMENT	IS PART OF	701 SYSTEM	M-1
310 DEVICE/INSTRUMENT	IS MOUNTED IN/ON	704 ELECTRICAL EQUIPMENT	M-1
310 DEVICE/INSTRUMENT	CONTROLS	704 ELECTRICAL EQUIPMENT	M-N
323 DEVICE TERMINAL	IS PART OF	352 ELECTRIC CIRCUIT	M-1
353 BUS COMPARTMENT	IS PART OF	704 ELECTRICAL EQUIPMENT	M-1
353 BUS COMPARTMENT	CONTROLS	704 ELECTRICAL EQUIPMENT	M-N
704 ELECTRICAL EQUIPMENT	IS A	750 MOTOR	1-1
704 ELECTRICAL EQUIPMENT	IS A	754 PANEL/ENCLOSURE	1-1

A.5 Step 4: Identify Related Activities

Since this application will be used for maintenance activities during the operations phase of the plant life cycle, it is assumed that the bulk of design and construction work will have already been completed. Consequently, only station modification work will be associated with activities in the design and construction phases. An examination of the flowpaths for the data used in the maintenance activities 4N01 and 4N02 reveals two activities that stand out among those that provide input data. These activities are Detailed Control System Design (2E16) and Panel/Cabinet Design (2E17). Between them, they supply most of the wiring and layout information to the instrumentation and electrical maintenance activities. These two activities also are predominant among those that could benefit from the application data, since the data provides an as-built status upon which to base further modification work. A simple chart showing the data flow between these activities is shown in Fig A-2.

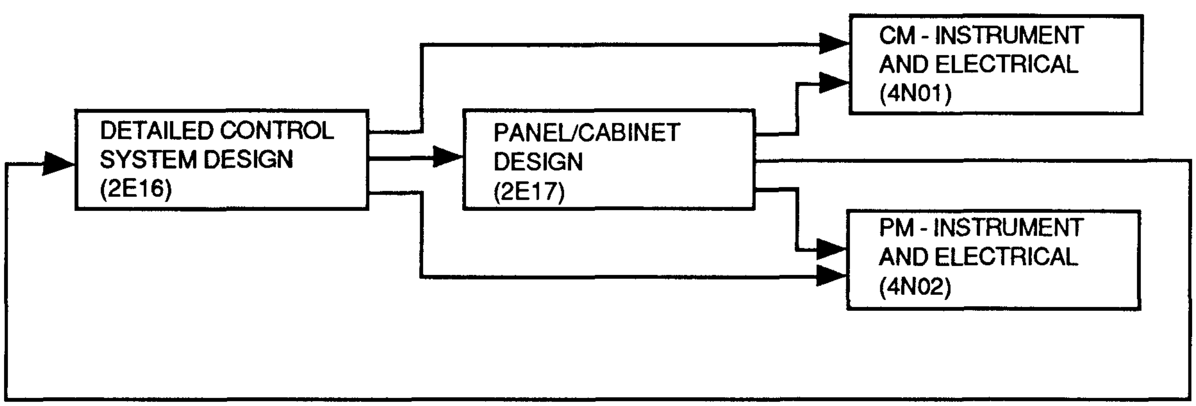

Figure A-2—Activity Flow Diagram for an Example Application

A.6 Step 5: Revise the Scope of the Application

The data provided to this application by the Detailed Control System Design (2E16) and Panel/Cabinet Design (2E17) activities were found to be already automated. No scope change is considered necessary for this input.

When analyzing the data flows into the application from the Panel/Cabinet Design (2E17) activity, it was recognized that much of this data is also used by the Equipment Seismic Qualification and Anchorage (2C15) activity. The proposed application identifies the devices that are wired in a circuit. It could just as easily identify the devices that are located in or on a given electrical panel, since this information is part of the data model for the application. If this capability along with the attributes WEIGHT, DIMENSIONS, and CENTER OF GRAVITY for DEVICE/INSTRUMENT, and the attribute MATERIAL AND WALL THICKNESS for PANEL/ENCLOSURE were added, then all the data would be available for the Equipment Seismic Qualification and Anchorage (2C15) activity to perform a seismic analysis of the panel. Since corrective maintenance could result in the replacement of a damaged part with a different model, it may necessitate a seismic qualification of the panel design. The scope of the application should be changed to include this enhancement.

A.7 Step 6: Economic Analysis

Generally, an economic analysis is performed prior to continuing with development. That aspect is very organization-specific and is not presented in this example.

A.8 Step 7: Customize the Application Data Model

As described in Step 5, the seismic qualification enhancement would require the addition of the attributes WEIGHT, DIMENSIONS, and CENTER OF GRAVITY for DEVICE/INSTRUMENT to the initial application data model produced in Step 3. In addition, the attribute MATERIAL AND WALL THICKNESS for PANEL/ENCLOSURE would have to be added. It would also be appropriate to add the attributes SEISMIC QUALIF.RPT.NO., SEISMIC AMPLICATION, and STIFFNESS FOR ELECTRICAL EQUIPMENT. Since the attributes CENTER OF GRAVITY for DEVICE/INSTRUMENT and MATERIAL FOR PANEL/ENCLOSURE are not in the PIN, the attribute number AA could be assigned to each.

The initial data model produced in Step 3 (see Table A-1) contains two attributes that must be specified in greater detail to support the functions of the application. The DEVICE/INSTRUMENT location should be identified more specifically, as shown in Table A-3.

Table A-3—Customized Attributes for Device/Instrument Location

PIN Attribute	Customized Attributes
LOCATION	FACE OF PANEL
	X-DIMENSION FROM LOWER LEFT CORNER
	Y-DIMENSION FROM LOWER LEFT CORNER

The value for FACE OF PANEL indicates upon which face of an electrical panel a device is located. The X and Y dimensions identify where on the panel face the device is located.

Likewise, the ELECTRICAL EQUIPMENT LOCATION should be broken down as displayed in Table A-4.

Table A-4—Customized Attributes for Electrical Equipment Location

PIN Attribute	Customized Attributes
LOCATION	BUILDING
	ELEVATION
	COLUMN LINE

These attributes define more specifically how the location of electrical equipment is identified. The customized attributes will help the maintenance personnel to locate the devices and equipment that must be tagged quickly.

No new entities or relationships were required for this application. However, the entity PANEL/ENCLOSURE was added to the entity/attribute list because of the need to maintain attributes that are distinct to panel/enclosure. The customized entity/attribute list for the application is shown in Table A-5.

The E-R table in Table A-2 and the E-R diagram in Fig A-1 are still applicable.

A.9 Step 8: Describe the Detailed Functional Requirements

Fig A-1 and Table A-5 can be used to describe the functions of the application in this example. This will be done for the first two objectives of the application. Entries from Fig A-1 and Table A-5 are given in all capital letters.

A.9.1 Function 1

The first objective for this application is to identify and locate the motorcontrol-center compartment that controls the motor requiring maintenance. This requirement could be stated as follows:

Given the ELECTRICAL EQUIPMENT IDENTIFIER (motor number), use the BUS COMPARTMENT CONTROLS ELECTRICAL EQUIPMENT relationship to determine the BUS COMPARTMENT IDENTIFIER (motor-control-center compartment number).

Then, using this BUS COMPARTMENT IDENTIFIER and the BUS COMPARTMENT IS PART OF ELECTRICAL EQUIPMENT relationship, determine the ELECTRICAL EQUIPMENT IDENTIFIER, BUILDING, ELEVATION, and COLUMN LINE for the motor control center, which is a piece of electrical equipment also.

With this information, the I & E maintenance staff could proceed to the motor control center, access the appropriate compartment, and disconnect the power to the motor.

A.9.2 Function 2

The second objective of the application is to identify each of the electrical devices that are part of the control circuit that drives the motor. The location of the devices (within the electrical cabinet), the function, the drawing number, and the general classification are to be determined also. The devices that control and monitor the motor are of particular interest, since these devices must be tagged and locked out while the motor is out of service. This requirement could be stated as follows:

Given the ELECTRICAL EQUIPMENT IDENTIFIER (motor number), use the DEVICE/INSTRUMENT IS MOUNTED IN/ON ELECTRICAL EQUIPMENT relationship to determine the DEVICE/INSTRUMENT IDENTIFIER, LOCATION, FUNCTION, and DRAWING NUMBER of the connection box.

Table A-5—Entity/Attribute List for a Motor Control Circuit Tracing Application (After Customization)

106	CIRCUIT WIRE	
	01	IDENTIFIER
310	DEVICE/INSTRUMENT	
	01	IDENTIFIER
	02AA	FACE OF PANEL
	02AB	X-DIMENSION FROM LOWER LEFT CORNER
	02AC	Y-DIMENSION FROM LOWER LEFT CORNER
	03	DIMENSIONS
	05	FUNCTION
	08	WEIGHT
	10	DRAWING NUMBER
	AA	CENTER OF GRAVITY
313	DEVICE/INSTRUMENT TYPE	
	01	UTILITY PART NUMBER
	27	GENERAL CLASSIFICATION
323	DEVICE TERMINAL	
	01	IDENTIFIER
352	ELECTRICAL CIRCUIT	
	01	IDENTIFIER
	05	FUNCTION
353	BUS COMPARTMENT	
	01	IDENTIFIER
701	SYSTEM	
	01	IDENTIFIER
	05	FUNCTION
704	ELECTRICAL EQUIPMENT	
	01	IDENTIFIER
	02AA	BUILDING
	02AB	ELEVATION
	02AC	COLUMN LINE
	05	FUNCTION
	07	TYPE
	39	SEISMIC QUALIF RPT NO
	51	SEISMIC AMPLIFICATION
	80	STIFFNESS
754	PANEL/ENCLOSURE	
	11	THICKNESS
	AA	MATERIAL

Then, using the DEVICE/INSTRUMENT IDENTIFIER and the DEVICE/INSTRUMENT CONTAINS DEVICE TERMINAL relationship, find the DEVICE TERMINAL IDENTIFIERs for the terminals of the connection box.

Then, using each of these DEVICE TERMINAL IDENTIFIERs and the CIRCUIT WIRE CONNECTS TOGETHER DEVICE TERMINAL relationship, determine the associated CIRCUIT WIRE IDENTIFIER of the circuit wire that is connected to the terminal.

Then, with the CIRCUIT WIRE IDENTIFIER and the CIRCUIT WIRE CONNECTS TOGETHER DEVICE TERMINAL relationship, find the DEVICE TERMINAL IDENTIFIERs for the rest of the device terminals on this circuit.

Then, using each of these DEVICE TERMINAL IDENTIFIERs and the DEVICE/INSTRUMENT CONTAINS DEVICE TERMINAL relationship, determine the DEVICE/INSTRUMENT IDENTIFIER, LOCATION, FUNCTION, and DRAWING NUMBER for the DEVICE/INSTRUMENT that contains the device terminal.

Then, use the DEVICE/INSTRUMENT IDENTIFIER and the DEVICE/INSTRUMENT IS DESCRIBED BY DEVICE/INSTRUMENT TYPE relationship to find the DEVICE/INSTRUMENT TYPE GENERAL CLASSIFICATION for the device/instrument. If the classification is for a control device (push-button) or a monitoring device (status light), then flag the device as one requiring special attention by the maintenance staff.

Once a device is determined to be classified as a control or monitoring device, all device terminals on that particular device can be identified and traced to other device terminals on other DEVICE/INSTRUMENTS until all the devices represented in the control circuit are identified. As each device is identified, its LOCATION (within the panel), FUNCTION, and associated DRAWING NUMBERS can also be determined.