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Depreciation Practices

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Staff Subcommittee on Depreciation of

The Finance and Technology Committee

of the

National Association of Regulatory Utility Commissioners

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FOREWORD

To the National Association of Regulatory Utility Commissioners (NARUC):

In 1937, realization of the importance of depreciation in public utility regulation prompted the National Association of Railroad and Utilities Commissioners to create a Special Committee on Depreciation. In 1939, that Committee was reconstituted under the reissued constitution adopted by the Association and given the status of a standing committee. A series of extended meetings was held by the Committee in the ensuing years, leading to the publication of a comprehensive report in 1943 on the entire subject of depreciation in public utility regulation. That report, an informative text on utility depreciation, was used by regulatory commissions and their staffs for many years and is still referred to today.

In 1961, the duties of the Committee on Depreciation were assigned to the Committee on Engineering, Depreciation and Valuation. Upon further consideration, the Staff Subcommittee on Depreciation was formed in May 1962. In September of that year, the Subcommittee decided to compile a *Manual of Depreciation Practices* using the 1943-44 Report of the NARUC Committee on Depreciation as a base. Emphasis was placed on the development of a manual which would be useful particularly to Commissions and Commission staffs. Work ensued over the next several years, resulting in publication of a manual of *Public Utility Depreciation Practices* in December 1968.

Time has proven the value of the 1968 manual, as it has well served the multitude of regulatory Commissioners and their staffs for many years. In the fall of 1984, however, the NARUC Engineering Committee questioned whether work should commence on revising the 1968 manual. After seeking and receiving input from the state commissions, it was decided to revise the manual and the work was assigned to the Staff Subcommittee on Depreciation. By early 1986 a proposed outline for the revised manual was developed, but work on the project did not begin in earnest until mid-1988. At that time the Staff Subcommittee on Depreciation was composed of the following members:

Darrell A. Baker, Alabama, Chair
Alyson Anderson, Idaho
James J. Augstell, New York
David J. Berquist, Michigan
Jack Butler, Arkansas
Eric de Gruyter, West Virginia
Edward H. Feinstein, FERC
Michael J. Gruber, Pennsylvania
E. C. Hostettler, ICC
William Irby, Virginia
Ramesh U. Joshi, California
Ben Kitashima, FERC
Daniel C. McLean, Washington
Kenneth P. Moran, FCC
Noel J. Sheehan, IRS
Mark Wilkerson, Florida
Steve Wilt, Oklahoma

In late 1988, the first assignments of specific chapters of the manual were made to several Subcommittee members and work on the text commenced. At a Subcommittee meeting in Oklahoma City in June 1989, several key decisions were made regarding the best way to proceed with the project. It was decided that the Subcommittee would meet at least twice a year to ensure that the project would continue to move forward despite the heavy demands on the authors' time caused by the hectic pace of events at their respective Commissions; and an external review committee, consisting of individuals designated by the Society of Depreciation Professionals and an internal review committee, consisting of several Subcommittee members, would review draft chapters once they had been revised in response to Subcommittee members' comments. The internal review committee was comprised of the following members:

Susan Jensen, Ph.D., STB, Chair
Fatina K. Franklin, FCC
William Irby, Virginia
Ronald Lenart, FERC

In the ensuing years the Subcommittee changed as Commission personnel changed. In August, 1991, following dissolution of the Staff Subcommittee on Engineering (to which this Subcommittee reported), the Staff Subcommittee on Depreciation was given NARUC standing committee status and was directed to report to the Finance and Technology Committee of NARUC.

Following the appointment of Fatina Franklin, of the FCC staff, as Subcommittee Chair in June of 1992, the project moved forward at a steady pace. As decided earlier, the Subcommittee also met twice in 1993 and 1994. Between meetings drafts and rewrites of the text were exchanged among Subcommittee members. In late February 1995, the Subcommittee met for four days in Washington, D.C., followed by lengthy conference calls. At those meetings all of the chapters of the manual were given final review before submission to the National Regulatory Research Institute for final editing.

The Subcommittee on Depreciation wishes to acknowledge the following individuals who authored the various chapters of the manual and its appendices:

James J. Augstell, New York, now retired
Darrell A. Baker, Alabama
David J. Berquist, Michigan
David M. Birenbaum, Missouri
Bryan Clopton, FCC
Fatina Franklin, FCC
Wade Herriman, FCC
Richard Huriaux, DOT
William Irby, Virginia
Dr. Susan Jensen, Ph.D., STB (formerly ICC)
Ramesh U. Joshi, California
Christopher Kotting, Ohio
Patricia Lee, Florida
Ronald J. Lenart, FERC, now retired
Clarence Mougin, Wisconsin
Steve Wilt, Oklahoma

The Subcommittee on Depreciation also wishes to acknowledge the following individuals who made major contributions toward the editing of the manual:

Scott Bohler, New York
Michael Dean, Maryland
Terry Fowler, Arkansas
Angelo Rella, New York
Emmanuel Tzanakis, FERC

The Subcommittee further wishes to express its appreciation to the members of the external review committee who provided valuable assistance and guidance to the Subcommittee:

Dave Ashbaugh, GTE Telephone Operations North
Thomas Clark, U S WEST Communications, now retired
Harold Cowles, Professor Emeritus, Consultant, now retired
John Ferguson, Deloitte and Touche
Thomas McKitrick, American Water Works Service Company
Donald Myers, GTE Service Corporation, now retired
Joe Poitras, Technology Futures, Inc.
Branko Terzic, Yankee Energy Systems, Inc. (formerly Comm., FERC)
Robert Warnek, Consultant, now retired
Ronald White, Ph.D., Foster Associates, Inc.

Finally, the Subcommittee would like to acknowledge its debt of gratitude to the National Regulatory Research Institute for its invaluable assistance in editing the text, ensuring consistency of presentation, and making publication possible.

Staff Subcommittee On Depreciation:

Fatina K. Franklin, FCC, Chair
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Darrell A. Baker. Alabama
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PREFACE

The purpose of this manual is to present background material and operating practices for the determination of depreciation of public utility property for regulatory purposes for use primarily by staffs of the various commissions. Background material sufficient for an understanding of depreciation practices is included. Our primary purpose has been to present current practices and methods of determining depreciation and to update the 1968 manual. Consideration has been given to situations where data are limited, as well as to those situations where more complete and sophisticated data are available. The 1943 and 1944 Reports of the Committee on Depreciation of the NARUC discussed in depth specific use of depreciation for corporate and regulatory purposes. The basic principles expressed therein relative to those subjects still apply, and we strongly recommend those sections of the 1943 and 1944 report for further study by Commission Staff interested in depreciation. More recent policy with respect to this subject can be found in subsequent opinions and orders of the various regulatory bodies that relate to depreciation practices.

The Depreciation Subcommittee attempted to be objective in presenting this subject and believes that it has factually presented depreciation practices as they are now used by both industry and Commission Staffs in this field. Methods and practices seldom or no longer used have been omitted or discussed only briefly. The reader can find further reference to such methods in Appendix D, Bibliography.

This manual is the work of a committee and the opinions expressed herein necessarily reflect some give-and-take to develop a composite report. These opinions in their entirety are not necessarily those of any individual member.

CHAPTER I

BRIEF HISTORY OF UTILITY DEPRECIATION

Early Court Decisions

The principles of depreciation and providing for depreciation expense were of little significance until this century. Because man was concerned with providing only for himself and his family, his recognition of the costs associated with tools of his trade came only at the time of initial purchase or at replacement. It was of little significance whether he waited and replaced the tool from current capital, or systematically set aside funds for eventual replacement of the tool.

With the Industrial Revolution, and its heavy dependence on expensive machinery, came the eventual realization that preservation of investment capital is as much a part of business costs as labor and materials. The "wear and tear" on equipment observed in the new industrial age led to the recognition that capital invested in the machinery was being "consumed" in the process of producing goods. Man had always been aware that tools were a necessity for production, but now he acknowledged that the owner of the capital is entitled to a return for its use, just as laborers are entitled to a return for their services.

The recovery of capital was tied to the useful life of a tool and was seen as a means of "keeping the business going." At the end of its life the tool would be replaced with another tool and so on. Therefore, it was easy to arrive at the misconception that the purpose of depreciation is to accumulate a capital "pool" for replacement purposes. As discussed in greater detail later, the purpose of depreciation is not to build a reserve for the future. Equipment may not be replaced and, even if it is, the capital requirements at the time of replacement may differ substantially from those of the past.

Providing for the preservation of capital is a relatively new concept; only in the last two centuries do we find use of the term "depreciation." In the 1835 Annual Report of The Baltimore and Ohio Railroad Company, reference is made and a dollar value assigned to "depreciation" as a charge for deterioration of the railway and machinery. Nevertheless, in the years shortly thereafter, depreciation had no universal meaning, and many terms were used to depict the different methods employed for depreciation accounting.

In the utilities, the movement toward uniformity in the definition of depreciation and depreciation methods was accelerated by the establishment of regulatory commissions. Prior to 1900, regulatory commissions were primarily concerned with service as opposed to cost. However, as costs received greater emphasis, the regulatory commissions were arguably the principal protagonists in establishing a uniform concept of depreciation.

The crystallization, as well as the fluctuation, of public concepts of depreciation are mirrored in the opinions of the courts. In *Eyster v. Centennial Board of Finance*, 94 U.S. 500 (1876), the Supreme Court held that it was not customary to consider depreciation as an expense of doing business.[1] Two years later in *United States v. Kansas Pacific Railway Company,* 99 U.S. 455, the Court again denied depreciation as an operating expense. However, by 1907, in *Illinois Central Railroad v. Interstate Commerce Commission,* 206 U.S. 441 (1907), the Court, without using the word "depreciation" stated:

> It would seem as if expenditures for additions to construction and equipment, as expenditures for original construction and equipment, should be reimbursed by all of the traffic they accommodate during the period of their duration, and that improvements that will last many years should not be charged wholly against the revenue of a single year.

A landmark utility depreciation case was *Knoxville v. Knoxville Water Utility,* 212 U.S. 1 (1909). In its decision, the Supreme Court for the first time discussed depreciation in a rate case and dealt with both depreciation expense and accrued or existing depreciation in the rate base determination. With regard to the determination of value, the Court said:

> The cost of reproduction is not always a fair measure of the present value of a plant which has been in use for many years. The items composing the plant depreciate in value from year to year in a varying degree. Some pieces of property, like real estate for instance, depreciate not at all, and sometimes, on the other hand, appreciate in value. But the reservoirs, the mains, the service pipes, structures upon real estate, pumps, standpipes, boilers, meters, tools, and appliances of every kind begin to depreciate with more or less rapidity from the moment of their first use. It is not easy to fix at any given time the amount of depreciation of a plant whose component parts are of different ages, with different expectations of life. But it is clear that some substantial allowance for depreciation ought to have been made in this case.

Of depreciation expense, the Court said:

> A water plant, with all its additions, begins to depreciate in value from the moment of its use. Before coming to the question of profit at all, the utility is entitled to earn a sufficient sum annually to provide not only for current repairs, but for making good the depreciation and replacing the parts of property when they come to the end of their life. The utility is not bound to see its property gradually waste, without making provision out of earnings for its replacement. It is entitled to see that from earnings the value of the property invested is kept unimpaired, so that, at the end of any given term of years, the original investment remains as it was at the beginning. It is not only the right of the utility to make such a provision, but it is its duty to its bond and stockholders, and, in the case of a public service corporation, at least, its plain duty to the public. If a different

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[1] Further information on court cases can be found in Appendix B.

> course were pursued, the only method of providing for replacement of property which has ceased to be useful would be the investment of new capital and the issue of new bonds or stocks. This course would lead to a constantly increasing variance between present value and bond and stock capitalization - a tendency which would inevitably lead to disaster either to the stockholders or to the public, or both. If, however, a company fails to perform this plain duty and to exact sufficient returns to keep the investment unimpaired, whether this is the result of unwarranted dividends upon overissues of securities, or of omission to exact proper prices for the output, the fault is its own. When, therefore, a public regulation of its prices comes under question, the true value of the property then employed for the purpose of earning a return cannot be enhanced by a consideration of the errors in management which have been committed in the past.

The Supreme Court again dealt with the issue of the depreciation reserve in *Louisiana Railroad Commission v. Cumberland Telephone Company,* 212 U.S. 414 (1909). The Court held that funds received to pay for depreciation should not be added to capital accounts. It ruled, however, that funds so accumulated should be treated as a reserve.

In *The Minnesota Rate Cases,* 230 U.S. 352 (1913), the Court decided that the extent of existing depreciation should be evaluated and deducted from a reproduction new value. In *Kansas City Southern Railway Co. v. United States,* 231 U.S. 423 (1913), the Court recognized obsolescence as a factor of depreciation. In *Galveston Electric Company v. Galveston,* 258 U.S. 388 (1922), it was decided that many items included in the overhead costs of original construction may be properly depreciated. By 1923, the principle of depreciation was so generally accepted that the Court in *Georgia Railway and Power Company v. Georgia Railroad Commission,* 262 U.S. 625 (1923), stated that the amount of depreciation "is one of fact."

In 1930, the opinion of the Court had changed and reflected the belief that depreciation expense should be based upon present value rather than original cost (*United Railways and Electric Company of Baltimore v. West,* 280 U.S. 234 (1930)). That opinion appears to have been overruled in the 1934 decision *Lindheimer v. Illinois Bell Telephone Company,* 292 U.S. 151, (1934), wherein the Court stated:

> The method is designed to spread evenly over the service life of the property the loss which is realized when the property is ultimately retired from service. According to the principle of this accounting practice, the loss is computed upon the actual cost of property as entered upon the books, less the expected salvage, and the amount charged each year is one year's pro rata share of the total amount.

In 1944, in *Federal Power Commission v. Hope Natural Gas Company,* 320 U.S. 591 (1944), the Court reaffirmed its decision in the Lindheimer case that annual depreciation based on cost is proper since the integrity of the investment is maintained and that nothing more than preservation of the investment is required.

Early Methods

With the recognition of depreciation expense by the Supreme Court in the 1909 Knoxville case, "provision for depreciation" gained general acceptance. However, the methodology for making the "provision" was the subject of continued controversy. Ultimately, depreciation accounting evolved into a methodology wherein amounts are charged as expense to each accounting period according to some predetermined plan for recovering the cost of depreciable plant during its service life. Some of the early methods of depreciation accounting were described in *Reports Of Committee On Depreciation For The Years 1943 And 1944* (*1943 NARUC Report*).[2] The most notable are discussed below.

Retirement Method

Under this scheme, the cost of a plant asset, such as switching equipment, generators, or railroad track, would be charged to a plant account at the time of purchase and then to an expense account only at the time of retirement. During its useful life, its cost would be retained unimpaired in the plant accounts, and in the interim nothing would be charged to expense for its use in operations. Although the useful life of the equipment was declining as services were provided and revenues generated, none of the cost of the equipment was charged against the revenues that it produced in each fiscal period. Consequently, from the installation of the equipment until its retirement, profits were overstated. Profits in the period of retirement were understated. This method is not generally sanctioned at this time.

Inventory or Appraisal Method

The inventory or appraisal method required an inventory of plant items when income statements were prepared, at which time the plant assets would be appraised and the difference between cost and the appraisal, or the difference between the previous and the last appraisal, was recorded as an expense in the income statement. This method, which apparently was the prevailing mode in early times, is not sanctioned today and is generally a discarded practice.

Arbitrary or Lump Sum Writedowns

At one time it was a widespread practice to record the cost of plant capacity in the income accounts by making arbitrary writedowns of plant assets. That is, writedowns were not based upon scientific studies but were a clear recognition, although crudely applied, of the fact that plant assets had to be charged off before their retirement. The method was a rough way

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[2] See NARUC, *Reports of Committee on Depreciation for The Years 1943 and 1944* (Washington, DC: NARUC, 1943).

of recognizing depreciation expense. It and the appraisal method were undoubtedly logical precursors of the statistical depreciation methods practiced today.

Replacement Method

Under the replacement method, the costs of original plant assets were charged to plant accounts but replacements were charged to expense. The underlying philosophy for this method was that replacements kept the property in 100% operating condition; hence, if the cost of replacements were recorded as operating charges, the cost of the original plant could remain intact. This scheme had three inherent weaknesses: (1) the replacements were not necessarily uniform, hence profits fluctuated not only with the volume and profitableness of business, but also in inverse ratio to the volume of replacements; (2) it made no allowance for the fact that certain items of plant would not be replaced, hence these had to be charged to expense when they were retired; and (3) items of property were carried in the books at full original cost without the diminution necessary to reflect the service capacity used up or consumed in operations. Thus, the method inflated the assets of the companies by failing to record the diminished utility of the property.

Retirement Reserve Method

The retirement reserve method recognized some of the deficiencies of the other methods, particularly of the replacement method mentioned above, and sought to overcome them by a combination of replacement accounting and reserve accounting. Under this scheme, many replacements of like kind were charged to expense and the costs of the original units were allowed to remain in the plant accounts. However, it was recognized that some items or units of property would not be replaced in kind, and that some items were too costly to be charged to maintenance even if replaced. Thus, it was deemed advisable to have a reserve for these items. The reserve was not calculated to measure, in terms of cost, that part of the plant used up in operations at any given time, but rather it was looked upon as a cushion or buffer sufficient to offset any plant retirement which might occur within a relatively few years. The reserve was built up by charges to expense under the label of "retirement" expense. Amounts thus charged were credited to the retirement reserve just as depreciation is accounted for today.

The retirement reserve method represented some improvement over the replacement method but still retained many of its inherent weaknesses. Chief among them was the failure to charge to expense the cost of property as it was consumed in operations. As a result, the cost of retired property was sometimes so great, compared with the retirement reserve account, that it was deemed necessary to spread the unrecovered cost of property consumed in past operations over future operating periods.

The retirement reserve method was in wide practice among public utilities for a great many years and was recognized in the Uniform Classifications Of Accounts recommended by the National Association of Railroad and Utilities Commissioners until 1936. [3]

Other Methods

Other, somewhat less noteworthy, schemes achieved some use during the long transition to current depreciation methods. One such scheme, which was essentially the same as the lump sum appropriation discussed previously, provided for direct "credits to the plant accounts." A variation of this plan, which was sometimes designated "amortization of capital," spread the lump sums over a two to five-year period. Other methods provided for a "contingent and renewal fund" and, later, others provided for a true "depreciation fund." Both of these methods involved funding of reserve accounts. The "Percentage of Revenue Plan" provided for charges to annual depreciation based on a fixed percentage of revenues.

Utility depreciation practices took a great step forward in 1913 when all telephone companies, then subject to the jurisdiction of the Interstate Commerce Commission[4], were required to use straight-line depreciation accounting. This was probably the first significant recognition that expenses in any period should bear some relation to the use of plant during that period.

Regulatory Statutes and Practices on Depreciation

The results of a recent survey of the state and District of Columbia utility regulatory commissions, the Federal Communications Commission (FCC), the Federal Energy Regulatory Commission (FERC), and the Interstate Commerce Commission (ICC) are shown in Appendix E. The responses detail the statutory authority and current policies associated with depreciation rate changes for each regulatory body. Also shown are the current depreciation techniques and procedures authorized by each regulatory body. Whole life and remaining life techniques, the equal life group (ELG) procedure and amortization of reserve deficiencies, which were addressed by the survey, will be discussed in later chapters.

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[3] The organization's name was changed in 1967 to National Association of Regulatory Utility Commissioners (NARUC).

[4] Agency reorganized as the Surface Transportation Board in 1996.

Evolution of Mortality Concepts

Previous sections discussed the evolution of methods for providing depreciation and the gradual development of practices that reflect the loss of "service value" of assets. The fact that physical structures depreciate over their life span was recognized by the Romans as evidenced by the following quotation from Vitruvius on Architecture, first century B.C.:

> Therefore, if anyone will from these commentaries observe and select a type of walling, he will be able to take account of durability. For those which are of soft rubble with a thin and pleasing facing cannot fail to give way with lapse of time. Therefore, when arbitrators are taken for party walls, they do not value them at the price for which they were made, but when from the accounts they find the tenders for them, they deduct as price of the passing of each year the 80th part, and so - in that from the remaining sum repayment is made for these walls - they pronounce the opinion that the walls cannot last more than 80 years.

The ICC Prescriptions

As early as 1907, the ICC prescribed depreciation accounting for steam railroads. In 1910, ICC accountants began work on a system of accounts for telephone companies, and many conferences were held with representatives of telephone companies, state commissions, and interested parties. On December 10, 1912, the ICC issued the Uniform System of Accounts for Telephone Companies (USOA) with annual operating revenues exceeding $50,000. This system of accounts, which became effective January 1, 1913, stated that "depreciation expense should be designed to recover the cost of plant over its estimated life in the case of individual units, and over the estimated average service life in the case of group properties."

FPC Regulations, 1921

The Federal Power Commission, in its Regulation #16 issued in 1921, required the establishment and maintenance of depreciation reserves by licensees of federal hydroelectric projects. The FPC was replaced by the Federal Energy Regulatory Commission by the Energy Act of 1977. Regulation #16 defined depreciation and detailed the character of property to be depreciated, as well as the methods to be used in computing and accounting for depreciation.

Mortality Concepts

The mortality concept in depreciation has roots in studies of human mortality experience and efforts to relate the results to a survivor curve or life table. Continuing the work begun by DeMoivre in 1725, Gompertz published an equation for such a curve in 1825. In 1860, Makeham advanced a modification of the earlier Gompertz equation. With recognition of the age-life relationship, the determination of service life and the related plant mortality characteristics assumed increasing importance in the consideration of depreciation. About 1920, the Bell System began a nationwide application of the Gompertz-Makeham formula to telephone plant and introduced the "life table" to depreciation studies. A detailed discussion of the Gompertz-Makeham equation is presented in Appendix A, parts 1 and 2.

The Iowa State Studies

The origin of the Iowa studies of industrial property mortality can be attributed to the initiative of Professor Edwin Kurtz, who in 1916 began to assemble data. The studies culminated with the 1931 publication of Bulletin 103, entitled "Life Characteristics of Physical Property," by Edwin B. Kurtz and Robley Winfrey. In Bulletin 103, Kurtz and Winfrey grouped 65 individual survivor curves, representing a wide range of physical property, into 13 survivor curve types. They reasoned that:

> Since the 65 mortality curves presented show very similar characteristics, they were redrawn so that the age was expressed in percent of average life and grouped into 13 classes from which the 13 type characteristics were drawn. The 13 type curves can be used as valuable aids in forecasting the probable future service lives of individual items and of groups of items of different kinds of physical equipment.

The classification of the survivor curves was made according to whether the mode of the frequency curves was to the left, to the right, or coincident with average service life. The result was standardized curves including four left modal (L1, L2, L3, L4); four right modal (R1, R2, R3, R4); and five symmetrical curves (S1, S2, S3, S4, S5).

Robley Winfrey expanded the base group of curves from 65 to 176 and the 13 types to 18, and published his work in Bulletin 125 of Iowa State University's Engineering Research Institute, entitled "Statistical Analysis of Industrial Property Retirements." Today, these survivor curve types, and later additions to them, which are commonly referred to as the "Iowa curves," are used extensively in depreciation studies. The Iowa curves and depreciation applications using the Iowa curves are discussed in Appendix A, part 3.

Statistical Concepts

Historically, accounting and other plant records kept by utilities contained a great deal of information awaiting statistical interpretation. However, techniques for statistical analysis of property retirements did not develop until the years just prior to and immediately following World War II. Stimulated in part by the *1943 NARUC Report*, depreciation literature that offered a number of statistical applications to depreciation analysis began to appear. Those applications are discussed in detail in later chapters.

Regulatory Jurisdiction Over Depreciation Practices

Many large utilities are subject to regulation at both the state and the federal level. Consequently, the approval of depreciation rates and the methods used to develop them were subject to multi-jurisdictional control. In the early 1980s, considerable debate arose over the methods used to compute service lives and the resulting depreciation rates for telephone companies. The FCC, in its 1980 Order for Docket No. 20188, amended Part 31 of the Uniform System of Accounts and authorized telephone companies to use the remaining life technique and the ELG procedure for depreciation accounting purposes. Several of the state commissions, however, objected to the proposed change in practices and refused to adopt all or part of them for use in their jurisdictions.

The FCC, in Docket No. CC 79-105 (1982), concluded that its interpretation of Section 220(b) of the Communications Act of 1934 was that states are precluded from departing from depreciation rates and methods prescribed by the FCC. The issue was ultimately decided by the United States Supreme Court, which ruled that the FCC lacked the authority to preempt states in matters relating to intrastate ratemaking procedures (*Louisiana Public Service Commission v. Federal Communications Commission,* 476 U.S. 355 (1986)).

CHAPTER II

CURRENT CONCEPTS OF DEPRECIATION

The preceding chapter outlined a number of different historical utility depreciation methods and concepts. This chapter presents two current depreciation concepts—value and cost allocation—and discusses several associated issues and considerations.

In everyday speech, depreciation generally means a decrease in the value or worth of an asset. The goal of depreciation is to allocate or assign a dollar amount to the reduction in worth or value occurring in each accounting period. This reduction starts when the asset is placed in service and usually continues throughout its life. The value of an asset is considered as being used up or consumed in the production of service. Consequently, a charge is made to the cost of production, over the asset's life, by some equitable method of allocation. Thus, depreciation accounting is fundamentally a process of allocating in a systematic and rational manner the value of a depreciable asset over its life.

Value Concept

The value concept assumes that all depreciable plant, due to forces such as obsolescence, wear and tear, and inadequacy, tends to diminish in value or worth with the passage of time. This value reduction may be dramatic—as when one purchases a new automobile. The new owner needs to do little more than drive it off the dealer's lot in order to put it in the classification of a "used car" with a value often substantially less than the purchase price. On the other hand, the reduction in value may occur much more slowly. For example, heavy duty manufacturing machinery will continue to perform the same operations in the same efficient manner for many years. Depreciation, in this sense, may not be consistent. If manufacturing machinery were producing a product that was in heavy demand for many years and suddenly lost its market, the machinery would rapidly lose value.

All other things being equal, on the day before this sharp demand decrease, the machinery would be nearly as valuable in the production of goods as the day it was first installed (assuming it had been kept in good repair). However, the day after the market disappeared the machine would be practically worthless or valueless.

Similarly, the installation of a new technology offering new or different services may cause existing plant to have little or no customer value. For example, a computerized supervisory control and data acquisition system (SCADA) may make the existing use of chart and pen recorders and the manual operation of gas city gate station valves unnecessary and uneconomical.

This situation suggests that depreciation can be determined through a series of periodic appraisals or estimates of plant value. The decrease in value between such estimates is regarded as a measure of the depreciation attributable to the period between estimates. The estimates could be based on the reproduction cost, market value, or earnings value of the property. Estimates may recognize the changing purchasing power of the dollar or they may be confined strictly to original cost terms. In all cases, some measure of depreciation occurring between estimates can be determined. The customary method is for a competent appraiser to study the effect of factors such as obsolescence, inadequacy, and public requirements, as well as to conduct a physical inspection of the property, or a scientific sample of it, to determine its loss in value since it was first constructed. Regardless of the method employed, in order to achieve consistency, the successive estimates must be made in the same way.

It would, however, be a staggering undertaking to attempt such estimates on an annual basis for complex and extensive utility plant. Therefore, the practice of conducting annual estimates has found little application in the utility industry. It is particularly cumbersome and inadequate because utilities need to record depreciation on a monthly basis for earnings and expense reports. A further complication, of course, is that major technological improvements tend to make questionable any year-to-year measure of depreciation that is determined by this process.

Cost Allocation Concept

This concept recognizes the original cost of the asset as a prepaid expense. As such, it must be allocated to specific accounting periods and realized on income statements during the time the asset is providing service. The unallocated amount, often called net plant or net book (gross plant less accumulated depreciation), is recorded on the asset side of the balance sheet. The cost allocation concept satisfies the accounting principle of matching expense and revenues.

On the income statement, the inflow of resources is revenue. The outflow is expense. Using up the productive capacity of assets in an accounting period is recorded in accounting records as depreciation expense.

As used above, "cost" is based on the cost valuation principle of accounting, with cost being a surrogate for value. The amount of money used to purchase the asset is the basis for the entry in accounting records. This amount is regarded as being definite and immediately determinable. The accounting objectives of verifiability and neutrality are also satisfied.

Equally important to the proper estimation of current net income is the recovery of the investment over its useful life. Depreciation accounting cannot, automatically and of itself, result in the recovery of investment in property. However, if revenues are adequate to cover depreciation expense in addition to other current expense, the investment will be recovered. On the other hand, if revenues are not sufficient to cover the depreciation expense, the investment will not be fully recovered. Recognition of depreciation merely records the fact that costs are being incurred.

Definitions

Before proceeding into an investigation of some of the associated procedures and problems, let us examine some important definitions of depreciation.

According to the Supreme Court of the United States:

> Broadly speaking, depreciation is the loss, not restored by current maintenance, which is due to all the factors causing the ultimate retirement of the property. These factors embrace wear and tear, decay, inadequacy and obsolescence. Annual depreciation is the loss which takes place in a year.[1]

The Interstate Commerce Commission defines depreciation as:

> Depreciation is the loss in service value not restored by current maintenance and incurred in connection with the consumption or prospective retirement of property in the course of service from causes against which the carrier is not protected by insurance, which are known to be in current operation, and whose effect can be forecast with a reasonable approach to accuracy.[2]

The National Association of Railroad and Utilities Commissioners in 1958 sanctioned the following definition:

> 'Depreciation,' as applied to depreciable utility plant, means the loss in service value not restored by current maintenance, incurred in connection with the consumption or prospective retirement of utility plant in the course of service from causes which are known to be in current operation and against which the utility is not protected by insurance. Among the causes to be given consideration are wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, changes in demand, and requirements of public authorities.[3]

The Federal Communications Commission uses a definition in Part 32 of its rules that is almost identical to NARUC's, except that it applies to "telephone plant" instead of "utility plant," and it requires that the causes of depreciation "can be forecast with a reasonable approach to accuracy."

The definitions used by the Federal Energy Regulatory Commission for electric (Part 101 of the Code of Federal Regulations) and gas (Part 201 of the Code of Federal Regulations) companies are essentially the same as that used by NARUC. The only difference is that the definition for gas companies recognizes the exhaustion of natural resources as a cause of depreciation for natural gas companies.

Sec. 167 of the Internal Revenue Code states:

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[1] *Lindheimer v. Illinois Bell Telephone Company,* 292 U.S. 151, 167 (1934).

[2] 177 ICC 351, 422 (1931), 14700 Depreciation Charges of Telephone Companies, 15100 Depreciation Charges of Steam Railroad Companies.

[3] *Uniform System of Accounts for Class A and Class B Electric Utilities,* 1958, rev., 1962.

> There shall be allowed as a depreciation deduction a reasonable allowance for the exhaustion, wear and tear (including a reasonable allowance for obsolescence)—(1) of property used in the trade or business, or (2) the property held for the production of income.

Some of the definitions refer to depreciation as a loss in service value. "Service value" is used in a special sense, meaning the cost of plant less net salvage (net salvage is gross salvage less the cost of removal). The Uniform System of Accounts for electric utilities recommended by NARUC defines "service value" as follows:

> The difference between the original cost and the net salvage value of the utility plant.

"Loss in service value," therefore, must be understood and construed in light of its specially defined meaning.

The American Institute of Certified Public Accountants in Accounting Research and Terminology Bulletin #1 defines depreciation accounting as follows:

> Depreciation accounting is a system of accounting which aims to distribute cost or other basic value of tangible capital assets, less salvage (if any), over the estimated useful life of the unit (which may be a group of assets) in a systematic and rational manner. It is a process of allocation, not of valuation. Depreciation for the year is the portion of the total charge under such a system that is allocated to the year. Although the allocation may properly take into account occurrences during the year, it is not intended to be a measurement of the effect of all such occurrences.

This definition of depreciation accounting brings the "allocation of cost" concept into much clearer focus. It de-emphasizes the concept of depreciation expense as a "loss in service value" or an "allowance" and emphasizes the concept of depreciation expense as the cost of an asset which is allocable to a particular accounting period. This definition also clearly illustrates that the goal is recognizing cost, not providing funds for replacement of the asset.

Factors Which Affect the Retirement of Property

The sole reason for concern about depreciation is that all plant devoted to the pursuit of a business enterprise will ultimately reach the end of its useful life. Several factors cause property to be retired. They include:

1. Physical Factors
    a. Wear and tear
    b. Decay or deterioration
    c. Action of the elements and accidents

2. Functional Factors
    a. Inadequacy
    b. Obsolescence
    c. Changes in the art and technology
    d. Changes in demand
    e. Requirements of public authorities
    f. Management discretion

3. Contingent Factors
    a. Casualties or disasters
    b. Extraordinary obsolescence

Physical factors are the most readily observed causes of retirement. However, functional factors sometimes are the more frequent causes.

Inadequacy is a lack of capacity to supply what is required or demanded. For example, a telephone company's central office switch may not have sufficient capacity to process the traffic generated, or it may be unable to provide certain information services desired by customers. Thus, it may be more prudent to replace the entire switch in lieu of making additions.

Obsolescence may bring about retirements by rendering plant uneconomical, inefficient, or otherwise unfit for service because of improvements in technology or because of changes in function. Equipment manufacturers may contribute to obsolescence by discontinuing production of replacement parts or de-emphasizing maintenance, software, or other kinds of support for older equipment.

Technological advances have increased the frequency in which obsolescence causes the retirement of utility plant. Computers, the electronic chip, remote controlled operation and supervision of power distribution stations and natural gas regulating equipment, remote meter reading, fiber optic cable, as well as interest in nonutility power production and demand-side management are technological developments that have impacted utility operations.

Changes in demand reflect changing customer preferences requiring the replacement of plant which no longer permits the utility to fulfill its obligation to provide service. An example is the replacement of electric kilowatt hour meters with meters that also record usage by time of day.

Public authorities may require utility plant to be relocated because of its interference with public uses, such as highway relocations. They also may require utility plant to be replaced or refurbished because its design fails to meet current service, environmental, or safety standards. An example is the imminent expiration of operating licenses for hydraulic production plants. This has often resulted in an extensive review of the safety, environmental, recreational, as well as power generation aspects of these projects. Substantial requirements for additional maintenance and capital expenditures may be required to satisfy the concerns of regulatory agencies and their constituencies.

Although not included in the previous definitions, management discretion clearly is also a factor in the retirement of plant. This can occur when management decides to:

1. Retire production plant, rather than extend its life;
2. Sell and lease back plant to affect cash flow;
3. Replace aging plant with new plant to enhance the corporate image;
4. Contract out functions which were formerly done by utility personnel and equipment in an effort to reduce costs;
5. Place surplus plant in storage in anticipation of future growth in demand; and
6. Retain removed plant that would normally be scrapped in anticipation of repairing it for reuse.

The advent of competition in markets that were historically monopolistic adds a new dimension to property retirements, particularly for incumbent public utilities. Competition may influence some or all of the functional factors. For example, a competitor may deploy modern technology, which may render the incumbent's equipment inadequate or obsolete because it cannot duplicate the competitor's new services or match a lower price enabled by the new, low-cost technology. Competition provides incentives to look for new technologies to provide enhanced or less costly services. Competition can also affect the demand for services if the competitor succeeds in obtaining a significant share of existing markets or creates new markets. And finally, because of competition, public authorities may require companies to do things that otherwise would not be done. For example, the FCC required local telephone companies to offer equal access interconnection to all long distance companies so that the companies could compete on equal terms.

Contingent causes are associated with such things as casualties and extraordinary obsolescence. Remote contingencies are not properly considered in establishing depreciation rates. For example, it would not be proper to include, as a cost of operation, a charge for depreciation because an earthquake might destroy property in a location where such a phenomenon is a rare occurrence. On the other hand, property retirements from ordinary storm damages, recurring more or less continually, are properly considered in estimating service lives.

Usually, any given retirement is a result of the inseparable action of a number of underlying causes. Public authorities, for example, may require that a fish ladder be installed at an existing dam, making retirement of some plant necessary. Physical deterioration of certain parts may take place such that high maintenance charges justify replacement of the whole with a more modern and more durable material or design. Reduction of the carrying capacity of water mains resulting from interior deposit buildup may cause them to become inadequate for the required loads. Shifting load centers may result in under-utilization of the facilities. This, in turn, may result in economic justification for substituting smaller, more efficient, or more economical facilities. The possibility of price increases, labor shortages, or functional changes may cause prudent management to replace large blocks of plant before physical deterioration or other factors materialize. What appears to be the cause may be only the final straw.

Methods of Allocating Depreciation Expense to the Accounting Period

Having developed the "allocation of cost" concept as being the most appropriate for day-to-day utility operation; having compared this concept to standard definitions of depreciation and found it to be compatible with them; and having discussed many of the factors that cause plant retirements, we can now consider the determination of the actual amount of depreciation expense to be recorded for a utility.

There are many ways, of course, to allocate the cost of property to the various accounting periods. One method is to charge to expense the total cost at the time of installation. This is known as "expense" accounting, which is used in lieu of depreciation, and is generally applicable to inexpensive and short-lived items. At the other extreme is "retirement" accounting which charges the cost of the property to expense in a lump sum at the time of its retirement from service.

The expense and retirement accounting methods fail to achieve the goal of distributing costs to the accounting periods during the property's life. Therefore, they would not properly match revenues and costs, and the accounting representation of net income would be distorted. Furthermore, the appropriate customer would not pay a fair share of the cost, assuming depreciation expense is included in the cost of service. Generally accepted accounting principles require expenses, such as depreciation, to be allocated by systematic and rational procedures to the periods during which the related assets are expected to provide benefits.[4] The simplest and most logical way to accomplish this is to use a method that distributes the cost of property in a reasonable and consistent manner to all the accounting periods in which the property is providing utility service.

Several methods for distributing these costs are explained in detail in other chapters. Generally these methods may be grouped as follows:

1. The **deferred** method assigns more depreciation expense to the later years of the life of the plant by applying compound interest formulas. Among the several variations of this approach are the "annuity," "sinking fund," and "compound interest" procedures.

2. The **accelerated** method assigns more depreciation expense to the earlier years of the plant's life. These methods have been allowed by the Internal Revenue Code for income tax purposes. "Sum-of-the-years-digits" and "declining balance" are two methods in this category. (see Chapter V).

3. The **straight line** method distributes the cost of property in equal annual amounts, as nearly as is practicable, over its life. This includes the "average service life" and "remaining life" procedures.

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[4] *Statement of Financial Accounting Concepts No. 5,* Financial Accounting Standards Board, December 1984.

Costs may also be distributed over production rather than over service life. This method, the unit of production method, distributes the costs as units are produced using a rate per unit developed from the total estimated units to be produced. It is similar to the straight-line method but is a function of production rather than a function of time.

Salvage Considerations

Under presently accepted concepts, the amount of depreciation to be accrued over the life of an asset is its original cost less net salvage. Net salvage is the difference between the gross salvage that will be realized when the asset is disposed of and the cost of retiring it. Positive net salvage occurs when gross salvage exceeds cost of retirement, and negative net salvage occurs when cost of retirement exceeds gross salvage. Net salvage is expressed as a percentage of plant retired by dividing the dollars of net salvage by the dollars of original cost of plant retired. The goal of accounting for net salvage is to allocate the net cost of an asset to accounting periods, making due allowance for the net salvage, positive or negative, that will be obtained when the asset is retired. This concept carries with it the premise that property ownership includes the responsibility for the property's ultimate abandonment or removal. Hence, if current users benefit from its use, they should pay their pro rata share of the costs involved in the abandonment or removal of the property and also receive their pro rata share of the benefits of the proceeds realized.

This treatment of net salvage is in harmony with generally accepted accounting principles and tends to remove from the income statement any fluctuations caused by erratic, although necessary, abandonment and removal operations. It also has the advantage that current consumers pay or receive a fair share of costs associated with the property devoted to their service, even though the costs may be estimated.

The practical difficulties of estimating, reporting, and accounting for salvage and cost of retirement have raised questions as to whether more satisfactory results might be obtained if net salvage were credited or charged, as appropriate, to current operations at the time of retirement instead of being provided for over the life of the asset. The advocates of such a procedure contend that salvage is not only more difficult to estimate than service life but, for capital intensive public utilities, it is typically a minor factor in the entire depreciation picture. The obvious exception, of course, is the huge retirement cost of decommissioning nuclear power plants. The advocates of recording salvage at the time of retirement further contend that salvage could properly be accounted for on the basis of known happenings at the date of retirement rather than on speculative estimates of factors, such as junk material prices, future labor costs, and environmental remediation costs in effect at the time of retirement.

One of the practical difficulties of estimating net salvage is that reported salvage is a mixture of salvage on items retired and reused internally, salvage on items sold externally as functional equipment, and salvage on items junked and sold as scrap. Because the likelihood of reuse is greater for items that are retired at early ages, the historical salvage is usually higher than the future salvage to be realized when the account begins to decline and there is little opportunity for reuse. Therefore, under these circumstances, book salvage may overstate the average salvage realized over the entire life of the account. This has led to the proposal to redefine net salvage and retirements to eliminate the effect of reused material. Reuse salvage is further discussed in Chapter III.

The sensitivity of salvage and cost of retirement to the age of the property retired is also troublesome. Due to inflation and other factors, there is a tendency for costs of retirement, typically labor, to increase more rapidly than material prices. In an increasing number of instances, the average net salvage is estimated to be a large negative number when expressed as a percentage of original cost, sometimes in excess of negative 100%. This may look unrealistic but is appropriate and necessary so that the required cost allocation occurs. Nonetheless, a careful analysis of retirements should be made to determine if such large negative net salvage values are due to unusual circumstances. An example is the retirement of old cast iron gas mains in congested metropolitan areas. Due to urban renewal, a utility may have a significant amount of such activity for a few years. Since most of the investment in this account may now be in plastic mains in rural or suburban areas where access is easier, the removal of old cast iron gas mains at today's cost may not be representative of the costs that can be expected for plastic mains.

While this situation should not impose insurmountable difficulties from a depreciation expense or cost allocation perspective, it presents an interesting problem from the standpoint of the rate base. Since rate base is generally the difference between book cost and accumulated depreciation, the provision for negative salvage further decreases the rate base. If the original book cost for old plant is less than the accumulated provision for depreciation, the rate base could be a negative amount.

As the foregoing discussion indicates, gross salvage, in contrast to service life, is usually small in its overall effect on calculating a depreciation rate. Cost of retirement, however, must be given careful thought and attention, since for certain types of plant, it can be the most critical component of the depreciation rate.

Group Plan

The group plan of depreciation accounting is particularly adaptable to utility property. Rather than depreciating each item by itself (unit depreciation) or depreciating one single group containing all utility plant, a group contains homogeneous units of plant which are alike in character, used in the same manner throughout the utility's service territory, and operated under the same general conditions.

Of course there will be different lives for individual units within groups. For example, poles are generally combined in a single group. Some poles will be retired because of storms or automobile accidents. Some will decay, some will be displaced due to road relocations and some will be retired because of underground replacements. However, they are combined in the same group because they are homogeneous units. Years ago when some poles were untreated, there was a need for a separate grouping as these poles were more susceptible to decay and termite infestation than treated poles. Likewise, concrete poles have unique characteristics and qualify to be grouped separately from wood poles. Buried, aerial, and underground (in conduit) cables are further examples of the same type of plant receiving different grouping because of different characteristics. Generally speaking, smaller groups yield more accuracy, but there are diminishing returns because more detailed accounting records are required.

Most utilities group properties by account and in some cases subaccount. Studies are made by using various procedures to determine the appropriate life and salvage factors. These procedures involve different forms of grouping for weighting purposes and should not be confused with the group concept of depreciation. Such weighting procedures include average life group, broad group, vintage group and equal life group. These weighting procedures are discussed in more detail in Chapter IX.

Depreciation in Taxation

No discussion about depreciation concepts would be complete without mentioning the interest and the role of the federal government regarding depreciation practices and their effect on the nation's economy. In the early 1950s the federal government recognized that industry expansion and modernization programs were financed to a considerable degree by internally generated funds from depreciation accruals. Further recognition of the fact that such programs benefitted the national economy generated additional interest in depreciation. Using the depreciation deduction for income tax purposes as its vehicle, Congress extended financial incentives to industry to expedite and magnify expenditures for new plant in the Internal Revenue Act of 1954. That Act permitted companies, including utilities, to use either the declining balance or sum-of-the-years-digits method to calculate depreciation expense for tax purposes. Under these accelerated methods, companies could claim higher depreciation expense deductions in the early years of plant life. The resulting reduction in taxes paid and normalization accounting for deferred taxes provided more funds for other corporate purposes, including plant expansion and modernization.

Since the 1954 Act, the federal government continued to amend depreciation policy. In 1962, guideline lives were established to be used in calculating annual depreciation expense. Guideline lives are lives provided by the Internal Revenue Service (IRS) instead of actual service lives based on individual company experience. The Asset Depreciation Range system, adopted in 1971, allowed taxpayers to vary the guideline lives up to 20%. After August 1, 1969, a utility could continue to flow through to its customers the benefit of accelerated depreciation unless its regulatory body allowed a change to normalization accounting. In 1981, the Economic Recovery Tax Act terminated flow-through of tax timing differences on investment placed in service after January 1981. Additional tax changes continued to evolve, such as those in the Tax Reform Act of 1986 and the National Energy Policy Act of 1992.

Most utilities operate under prescribed systems of accounts which do not allow accelerated depreciation for regulatory accounting purposes. If these utilities elect to use accelerated depreciation for income tax purposes, a difference between book and tax depreciation expense occurs.

It is important to note the difference in purpose of book depreciation and tax depreciation. Book depreciation is a cost allocation process used to satisfy specific accounting and regulatory principles and requirements, whereas tax depreciation provides additional tax and financial incentives unrelated to the strict cost allocation process.

Impact of Inflation and Deflation on the Recovery of Capital Through Depreciation Practices

Today's regulatory depreciation practices almost universally require charging the original cost of property as an expense to the various periods of operation. There is one important difference between depreciation expense and most other expenses. Depreciation expense is recovered with current dollars but is an allocation of a historical cost which was incurred years earlier. During sustained periods of inflation or deflation, the question arises: Should an adjustment be made to the depreciation expense in order to compensate for this value fluctuation?

The primary aim of depreciation under the original cost concept is to maintain the integrity of the original capital invested in the business. By reinvesting depreciation accruals, the capital investment in total dollars does not change even though the physical assets may change. In periods of rapid change in the purchasing power of the dollar, however, the integrity of the original capital investment is not strictly maintained. This is because accruals over the life of the original plant will equal the same number of dollars originally spent, but the dollars collected will purchase more or less new plant depending on whether inflation or deflation has taken place and whether technological enhancements have created more economical plant.

It is generally accepted that the cost of money includes an inflation component to compensate lenders for the reduced purchasing power of the repaid principal. The dollars paid by customers because of this inflation component are typically treated as a return <u>on</u> capital, not as a return <u>of</u> capital. Some have proposed removing the inflation component from the rate of return and including it in the depreciation schedule for equipment. This "economic depreciation" produces a series of annual accruals that increases with time, as opposed to the constant accruals with straight-line depreciation.

This concept erroneously implies that these adjustments are intended to ensure that at the end of the life of any item, there should be sufficient dollars in the accumulated depreciation account to replace the item at then current prices. This is unlikely, as no one can predict future replacement costs years in advance. Also, this approach amounts to having customers make contributions-in-aid-of-construction which will not accrue interest, which is not appropriate. Depreciation expense is accrued in installments over the life of the property. These installments are available for reinvestment in new property or other purposes as management deems appropriate.

In its *1943 NARUC Report*, the NARUC Committee on Depreciation reached the following related conclusions:

1. A cost depreciation base is consistent with the fundamental concept of depreciation as resulting in a cost of operation.

2. Cost of plant is a definitely known amount and is not subject to the vagaries of estimates of value or of replacement cost.

3. The use of cost as a base permits ready ascertainment of depreciation charges and facilitates the making of operating forecasts.

4. The use of cost as a depreciation base tends to prevent manipulation of depreciation charges for financial expediency because the percentage of depreciation charges to plant is readily apparent from consideration of the income and balance sheet statements.

5. A cost depreciation base conforms to the accepted accounting principle that operating expenses should be based on cost and not be influenced by fair value estimates nor by what costs may be at some future date.

The 1954 report of the Committee on Depreciation revisited the matter of a proper depreciation base and concluded:

> This Committee's re-examination of the question as to what is the proper depreciation base, leads firmly to the conclusion that the claims advanced in support of economic depreciation are lacking in probative force. The Committee is convinced that the long-established cost basis is sound, practical and equitable and should be continued.

As a result, economic depreciation is not used in a regulatory environment.

Regulatory Considerations

Under traditional rate base, rate of return regulation, measurement of the rate of return produced by present or prospective rates for service is important. The rate of return is the ratio of two quantities: net earnings after expenses and rate base.

At least since the decision in the *Knoxville Water Company*, 212 U.S. 1, (1909), depreciation has been recognized in both the numerator and the denominator of this ratio, in that the expenses in the numerator include depreciation and the property investment in the denominator is after deduction of an amount to cover accrued depreciation. Since the Knoxville case, there has been increased awareness that there should be a consistent relationship between depreciation expense and accumulated depreciation *(Lindheimer v. Illinois Bell Telephone Company,* 292 U.S. 151, (1934)). That is, the depreciation deducted from rate base should be consistent with the annual depreciation expense.

If the objective is consistent treatment of depreciation, there are a number of questions which must be decided before a regulatory body arrives at an equitable final result. A number of regulatory bodies prescribe depreciation rates for utilities under their jurisdiction. The FCC, for example, prescribes rates for large telephone companies. It revises them every three years after receiving basic data, depreciation studies, and recommended rates submitted by the utility.

Prescribing depreciation rates is one of the most important regulatory commission activities impacting customer rates. The estimation of depreciation parameters is not, of course, a scientifically exact process, since it involves a large element of informed judgment regarding future developments. At the same time, it cannot be an arbitrary figure selected for convenience, because it must allocate the full cost over the life of the property in a rational manner. The depreciation rate is a calculated figure, and there is a zone of reasonableness within which the underlying parameters may be expected to lie.

If there is to be consistency between the numerator and the denominator in the rate of return calculation, the same depreciation deducted as an expense in the numerator must also be deducted in establishing the rate base in the denominator. Depreciation expense is a one-time entry affecting only the current year, whereas its inclusion in the depreciation reserve deduction from rate base is cumulative. As long as dollars remain in the reserve, they reduce the rate base and affect the amount of annual revenue required for return and income taxes.

The regulatory body prescribing depreciation rates is thus confronted with a decision which affects both the short-run and long-run interests of the customer and the company. If a commission prescribes rates which yield depreciation accruals that are too low, the revenue requirement in the short run may be lower. But the requirements for income taxes and return may offset the apparent savings in depreciation expense, so service rates in the long run may be higher. If depreciation rates are set so low that the revenue requirement fails to repay the capital invested in a group of property by the end of its service life, confiscation takes place or the unpaid cost remains in the rate base until amortized or expensed. On the other hand, if the regulatory body establishes depreciation rates toward the upper end of the zone of reasonableness, rates for service will be higher in the short-run, but may be lower in the long-run.

It is essential to remember that depreciation is intended only for the purpose of recording the periodic allocation of cost in a manner properly related to the useful life of the plant. It is not intended, for example, to achieve a desired financial objective or to fund modernization programs.

As pointed out earlier in this chapter, the depreciation expense reflected in the numerator of the rate of return calculation is almost always developed under the cost allocation concept. Consistency between numerator and denominator is easier to achieve, or at least easier to demonstrate, if the rate base is also developed under the same concept.

Some jurisdictions may consider a fair value rate base determined by considering reproduction cost, trended original cost, or an appraisal from which an appropriate calculated or observed depreciation reserve is deducted. The fair value rate base is used with the current cost of capital concept of rate of return. It is intended to reflect current economic facts based on the actual property involved and the conditions surrounding its use.

When the rate base is established using the cost allocation concept, the question of whether the depreciation deduction from rate base should be based on the actual depreciation reserve or on a calculated "theoretical reserve" arises. The latter may be defined as an estimate of the balance which should be in the depreciation reserve today, considering the distribution by ages of existing property, and assuming the correctness of the currently effective service life parameters and net salvage percentages. The theoretical reserve is calculated by deducting from the original cost the estimated future accruals at current rates and the estimated future net salvage credits or charges. The theoretical reserve may be either higher or lower than the book reserve.

The choice between using the book or theoretical reserve in calculating rate base depends on the conditions of the particular case. If, for example, depreciation rates have been prescribed by regulatory authorities for an appreciable period in the past, it would be inconsistent to deduct, in establishing a rate base, a larger or smaller amount than the book depreciation reserve accumulated under the prescribed rates. Consequently, under these conditions the book reserve would be proper. However, if a utility, of its own volition, makes inadequate provision for depreciation, consideration should be given to using the theoretical reserve since it may not be fair to make future customers pay for an incorrect management decision. There are, of course, many other possible combinations of circumstances that call for the exercise of informed judgment on the part of the regulatory authority in order to achieve consistency and equity.

Another important regulatory consideration is the extent to which a regulatory body should be involved in setting depreciation rates. Under traditional forms of regulation, primarily rate base, rate of return, regulators correctly chose to be heavily involved in prescribing depreciation rates because utilities were largely monopolistic and depreciation made up a large part of the revenue requirement. However, with the onset of competition and technological change, some regulatory bodies adopted alternative forms of regulation which place less emphasis on regulating profits and more emphasis on allowing competition to effectively regulate prices for competitive services. As a general rule of thumb, as long as commissions regulate or have oversight over earnings, they should continue to keep close scrutiny over depreciation rates. Once a commission abandons rate of return regulation, it should concurrently reexamine its policy of prescribing depreciation rates.

The Relationship Between Depreciation Expense and Capital Recovery

After receiving authorization for revised depreciation rates from a regulatory commission, the utility must use those rates to determine its book depreciation expense for regulatory purposes. It may be the case that the utility's tariff rates are too low to provide adequate revenue to cover ongoing operating and maintenance expenses in addition to the new level of depreciation. In this circumstance, there may not be full capital recovery in the sense that the stockholders may not be receiving the return they expected.

Thus, when depreciation rates, and hence expenses, are changing dramatically, it is important for the utility to attempt, to the extent possible, to coordinate the implementation of revised tariffs with the new depreciation rates. This may be done by making depreciation rates subject to review in a general rate case. Another method is to have a separate proceeding to determine depreciation rates. These rates are put into effect coincident with the regulatory commission's order approving tariffs that reflect the new depreciation rates. However, use of the remaining life depreciation procedure complicates this goal, because these rates should be implemented coincident with the depreciation study date, which will likely not coincide with revised tariffs.

CHAPTER III

ACCOUNTING FOR PLANT ASSETS

Nature of Plant Assets

As other chapters have shown, plant assets are commonly defined as those expenditures that are of a physical nature and benefit more than one accounting period. The benefits that the asset produces may be in the form of services or products that generate revenue. Since an expenditure for an asset which will be used as a productive resource in the utility business is made in one period but is expected to produce benefits for several periods, it is appropriate to allocate the cost of the expenditure over the periods in which service is provided. Historically almost all plant assets were tangible; they had a physical form. Examples are land, buildings, electric generators, compressors, switching equipment, the cables used to transmit electricity or telecommunications, pipelines, vehicles, and office equipment. Since land does not have a limited life, and since the cost of land is not allocated over the time the land is owned by the utility, its cost is not considered to be amortizable or depreciable.

Franchises, rights of way, land rights, copyrights, and computer software are examples of intangible plant assets. The useful life of franchises and copyrights may reasonably be expected to end at some point, so the dollar cost of such intangible plant assets is typically amortized over a period of years. Amortization is the allocation of costs of assets having a limited life over the accounting time periods of their life. The useful service life of rights to use land may be considered to cease when the utility equipment that occupies the right of way is removed or abandoned. Computers and associated software (operating software, programs and data) are assets that are a mix of tangible (hardware) and intangible (software) plant. Accounting for these mixed assets may be accomplished by dividing the overall investment into categories that may be depreciated or amortized, as appropriate.

Depreciation accounting is the systematic allocation of the cost of the asset over its useful life. This chapter will focus on the accounting for plant assets that experience a loss of service value over their lives. This loss is recognized by allocating a portion of the original cost to each of the periods of service or to the units of product which the asset provides.

Classification of Assets

Plant in service is accounted for in numerous individual account classifications that reflect the specific function or type of asset. Plant assets are classified on the basis of their use in providing service to the customers of the utility.

Plant in service consists of assets presently used in the utility's business. It can be defined as plant owned and used by the utility in its utility operations and with a life expectancy of more than one year from the date of installation. Plant in service is the largest classification of assets in terms of dollar amount, physical quantities, and accounting detail. It is the most important classification from a regulatory standpoint because it makes up the bulk of rate base.

Under the systems of accounts prescribed by most regulatory commissions, plant in service is classified into numerous primary accounts and subaccounts. Each account and subaccount becomes a separate depreciable base if the utility determines and applies depreciation rates on an individual account or subaccount basis.

Plant in service may also be classified by groupings of primary plant accounts which are related because of the type of service provided. For example, the Federal Energy Regulatory Commission's (FERC) Uniform System of Accounts (USOA) classifies electric plant accounts into the following functions: (1) Intangible Plant; (2) Production Plant, which is subdivided into (2A) Steam Production, (2B) Nuclear Production, (2C) Hydraulic Production, and (2D) Other Production; (3) Transmission Plant; (4) Distribution Plant; and (5) General Plant. A number of primary accounts are prescribed for each main class or subclass function. A primary account is a group or multiple asset account in which the additions, retirements, and transfers of similar kinds of property being used for a particular function are recorded. For example, a type of pipeline used by a gas company may be recorded in Production Plant if used in connection with the extraction and gathering of natural gas, in Underground Storage Plant if it is used for that purpose, or in Transmission Plant if it is used to transport natural gas to customers.

Plant recorded in the Property held for future use account is the plant owned by the utility but held for future use under a definite plan. Plant under construction is also known as construction work in progress. It is the total balance of construction work orders for utility plant presently being built.

The Retirement work in progress account is used to record the costs of the removal and disposal of retired plant. The recording of the realized gross salvage and cost of removal may occur in a later year than the retirement of the equipment. This results in a timing difference that the analyst should take into consideration.

Nonoperating plant consists of plant and equipment assets that are not properly part of the plant in service because they are not providing service to the utility customers under the rules and tariffs of the regulatory commission.

Utility companies may subdivide the primary accounts to provide more homogeneous groups. For example, a gas pipeline company may classify transmission compressor engines into subclasses, such as electric, reciprocating gas, and gas turbine; or an electric company may divide its transmission conductors into subaccounts according to their operating voltages.

Depreciation Considerations

Utilities generally conduct depreciation studies for each account to determine the life and net salvage factors to be used to calculate the depreciation rate on a straight-line basis. This rate is then applied to the average of the plant balances at the beginning and end of the period to determine the depreciation expense for that period.

Utilities may conduct periodic depreciation studies on an account basis and weight the resulting depreciation rates by the plant investment to develop composite rates that are then applied to functional classes or functional groups of properties. In such instances the functional class becomes the depreciable plant or depreciation base to which the composite depreciation rate is applied.

Studies based on individual plant accounts or subaccounts are preferable to those based on the broader functional groups of accounts because the individual circumstances and characteristics of each account can be recognized. Broader groupings of plant tend to make the identification and estimation of factors that will affect the expected life and net salvage more difficult.

When a composite rate is used to calculate depreciation expense, it is necessary to eliminate nondepreciable assets, such as land, from the total of functional plant. The depreciation expense of depletable assets or assets having a distinctive life cycle which are being depreciated using the unit of production method, and amortizable assets such as franchises or land rights, would be calculated separately.

Basic Principles of Accounting for Plant Assets

The government agencies and commissions that regulate public utilities typically prescribe a USOA that the utilities must follow. The USOA, which consists of definitions, rules, and instructions that utilities are required to follow, permits the business activities of the utility to be recorded in a consistent and logical manner.

One of the fundamental principles contained in all USOAs is the historical cost principle. That is, the dollar amount of an asset recorded in a plant account must be its original cost, i.e., the cost of the asset at the time it was first put into utility service. It is a verifiable amount, supported by source documents such as vendors' bills and construction work orders.

Book Accounting Data

Book accounting data are the dollar quantities identified in a utility's financial statements. For long-term assets, such as plant and equipment, the dollar cost is reported in summary form on the balance sheet of the annual financial statements contained in the report to stockholders and the annual report to the regulatory commission.

The dollar amount of plant in service is shown on the balance sheet which is supported by the general ledger which in term is supported by the property ledger. This ledger contains the detail of plant by functional group (if functional groupings are used), primary plant account, and subaccount. Supporting the property ledger is additional detail, which is sorted by taxing authority for property tax assessment purposes and by responsibility area, such as power plant location, or sorted by geographic region for administrative purposes.

Plant is defined in terms of property units and retirement units, which are in turn defined in the USOA of regulatory commissions and, in greater detail, by the utilities. A retirement unit is an identifiable item of plant. At one extreme it may be a gas-fired peaking plant. At the other extreme it may be a pole, a length of conductor, or an item such as a tool. Retirement units, when retired, with or without replacement, are accounted for by crediting the book cost thereof to the appropriate plant account.

Continuing Property Records (CPR)

In jurisdictions where a USOA requires work orders and property record systems, depreciation study data are available as long as the property record system has been adequately maintained and meets certain objectives. The basic objectives of CPRs are:

1. To create an inventory of utility property that may be readily verified for proof of physical existence; the recorded accountability for assets should be compared with the existing assets at reasonable intervals and appropriate action should be taken with respect to any differences,[1]

2. To associate costs with property record units to ensure accurate accounting for retirements, and

3. To determine dates of installation and removal of plant retired to provide data for use in connection with depreciation studies.

A properly maintained CPR system documents the plant in service as well as the capital invested in that plant. For this reason, maintaining these records is considered good business practice vital to the utility's operation. The CPR is a utility's support for the major portion of its rate base.

Each utility should record all construction and retirements of plant by means of work orders or job orders. Separate work orders may be opened for additions to and retirements of plant, or the retirements may be included with the construction work order, provided that all items relating to the retirements are kept separate from those relating to construction.

The work order system should show the nature of each addition to or retirement of plant, the total cost thereof, the source or sources of costs, and the plant account or accounts to which the addition or retirement has been charged or credited. Work orders covering jobs of short duration may be cleared (closed to the plant ledger) monthly.

Each utility should maintain records in which, for each plant account, the amounts of the annual additions and retirements subsequent to the effective date of the USOA are classified so as to show the number and the cost of the various record units or retirement units. For identifiable major units such as central office switching equipment, electric generators, or gas compressors, the records should include:

1. The description of the equipment,
2. Its location,
3. The cost, and
4. The plant control account to which the cost is charged.

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[1] NARUC Committee on Engineering, *Model Valuation, Plant Costs and Continuing Property Records Manual* (Washington, D.C.: NARUC, 1974), 28.

For mass property such as conductors, poles, and office furniture the record should include:

1. A description of the property and quantity,
2. The quantity placed in service by vintage year,
3. The average cost, and
4. The plant control account to which the cost is charged.

Cost data is usually not maintained separately for each unit of mass property, but is maintained as a vintage average cost for similar units of the same vintage or a cumulative average cost for a band of vintages. Considering the many vintages likely to occur in most accounts, a single cumulative average cost for all units in an account would not be suitable for determining the cost of retirements. For example, the inventory record should also include a general description of the property, the physical quantity in service by vintage year or band of vintages, the average unit cost, and the plant account to which costs are charged.

The entries in the property ledger should include the location, vintage, description, company serial number, and cost of the asset. To avoid undue refinement in accounting for additions, retirements, and replacements of plant, all property should be considered as consisting of retirement units and minor items of property. Each utility should use the list of retirement units prescribed by the regulatory commission, with the option of using smaller units. Each utility should file with the commission any changes to its list of retirement units as they occur.

The journal entry is the first record of the transaction on the utility's books. The entries in the property ledger are initiated by journal entries which record the transaction of acquiring plant. At the end of an accounting period, the journal entries are transferred to the property ledger, and the plant additions, transfers, and retirements are recorded in the property ledger. The journal entries must be supported by source documents, such as bills from vendors, records of payments, construction work orders, and written verification of completion of the work.

There are two ways of accounting for utility plant—location life and cradle-to-grave. Much of the utility's equipment is immobile, such as gas transmission pipelines, electric conductors, and buildings. Such utility equipment is accounted for on a location life basis. That is, when the equipment is received it is charged to the construction work in progress account or to the materials and supplies account. When the construction project is completed, the work order is closed. The construction work in progress account or materials and supplies is credited and plant in service is debited for the cost of the equipment. Other costs, such as labor, supervision, insurance and administrative costs are also debited to the plant account when the equipment is placed in service. The nature of the equipment is usually such that its location is fixed, such as in the case of a gas compressor station or an electric generator. It stays at the same location for its entire useful life. When immobile equipment is removed from its location, it has no remaining usefulness to the utility and is retired.

The USOAs for utilities generally require that the cost of equipment be recorded in the plant in service accounts only when the equipment is actually first placed in service. When the equipment is no longer needed at a given location, it is retired from service and either abandoned in place, removed, or returned to a storage facility for eventual refurbishment and redeployment or disposal. If the equipment is held for reuse, the related accounting entries are credit plant and debit accumulated depreciation for the original cost of the retirement; debit material and supplies and credit accumulated depreciation for the material cost that is being reused. However, some types of utility assets have so many placements, removals, and redeployments over their service lives that recording these related accounting entries would be excessively burdensome. These moves may be caused by the changing needs of customers or the need to test the equipment. Examples of equipment that frequently move are electric distribution transformers, gas regulators at the customers' premises, and electric and gas customer meters. For this equipment, cradle-to-grave accounting can be an efficient means of recording some types of equipment. This equipment is recorded in the plant in service account when it is received from the manufacturer and remains there until final retirement. This accounting avoids the complexities of recording each change in status.

In cradle-to-grave accounts, the number of spare units should be reviewed to determine if it is excessive. Regulators should consider the availability of replacement units or parts from the manufacturer, delivery lead times, withdrawals in recent years, and the condition of the spare equipment.

Depreciation Study Data

There may be circumstances where data other than accounting data are used in depreciation studies. Information on the types of equipment retired and surviving, and on terminal retirements as opposed to transfers, may be available in the form of operating and maintenance records. For example, studies based on the number of meters surviving and retired, rather than the recorded costs of meters surviving and retired, may be used. Several kinds of transactions provide data for depreciation studies. These are discussed below.

Addition

An addition is the result of completed construction work in progress or the purchase of equipment that will be used by the utility to provide service to customers under tariffs and conditions approved by a regulatory commission. Additions are typically paid for by sources of cash, such as the sale of debt instruments, equity in the utility such as stock, or internally generated funds. Customers or governmental agencies may contribute funds for the construction of plant that is normally not required by the responsibility to provide service. This is discussed in the Valuation Problems and Special Regulatory Considerations section of this chapter.

Ordinary Retirement

Recovery of the original cost of an ordinary retirement depends upon depreciation accruals and net salvage. Ordinary retirements are caused by such factors as wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, and changes in demand. Ordinary retirements may be classified in terms of location (reusable) retirements and final retirements.

The cost of the equipment to be retired should be identifiable directly from the CPR if costs are maintained by unit of property and vintage. Vintage information may be available from work orders or drawings.

Use of one average cost for all vintages may give longer or shorter life indications than what is actually being experienced, depending on the effects of inflation. Rather than use the current average cost for pricing retirements, the assumption may be made that retirements are a certain number of years old, such as ten years. Then the average unit cost at that time in the past would be used to price retirements. For example, the cost can also be determined using published statistics of annual inflation to deflate current costs to the time of installation.

Retirements may be priced on a first-in first-out basis. However, since the plant retired may not always be from the oldest vintages, the cost of retired plant would be understated since inflation would cause increases in the cost of the plant. This understating of retirements will lead to longer life indications than if vintage costs were used.

Reimbursement

A reimbursement is a retirement of property for which the company is compensated at the time of retirement through insurance because of the occurrence of a covered incident, or by public authority, customer, or other party as a result of negotiations wherein the property will be removed or relocated for the convenience of the entity desiring the retirement. In the case of insured losses, the payment received may be different from the original cost of the equipment. Thus, treating the reimbursement as normal gross salvage data in studies may give results that are not typical of the account as a whole because the insurance payment is not a characteristic of the account in general. Therefore, such retirements and the corresponding salvage should either both be included or excluded from the depreciation study. The accounting for removals should be analyzed to identify the apportionment of monies received among an offset to new construction, gross salvage, and cost of removal.

Sale

Property is sometimes retired because it is sold. The sale is made to a similar company for a continuation of service, e.g., sale of pole lines to a municipality. Sales at the end of the life or because the property is no longer useful for normal economic reasons are classified as ordinary retirements.

Transfer

A transfer is an accounting entry which removes property from one account and concurrently reassigns it to another account within the company. The reason for the transfer may be a change in operations such as reclassifying plant from transmission to distribution plant or moving furniture from the general office building to a generating plant. Transfers are not additions or retirements. In depreciation studies, transfers should be analyzed and the data should be revised to show the plant as if it had been in the proper account from the beginning of its service. Work papers should be retained so that the method and the results of this analysis are readily obtainable.

When a transfer of plant is made, it is imperative that a corresponding transfer of the depreciation reserve is also made. Otherwise, the reserve will be overstated for the originating account and understated for the receiving account. As long as the investment dollars are in a given account, depreciation is being accrued, and the accumulated amount should be transferred with the associated plant amount. In addition, the year of placement, age, and proportion surviving of the investment being transferred should be carried with the investment so that the transfer can be properly placed in the age distribution of the receiving account.

Acquisition

An acquisition is the purchase from an operating utility of plant that will be used in the same or similar type of service. The original cost is recorded in the plant in service account and the amount of the accumulated provision for depreciation is recorded in the appropriate account. Acquisitions may occur as a result of mergers or the purchase of units of property. In depreciation life studies, the data on additions should be adjusted to put the acquisitions at the vintage when they began service.

Adjustments

Adjustments may either increase or decrease the amount of plant exposed to retirement but cannot be associated with the other previous classifications of data. If entries are made to correct past errors, only those errors that cannot be identified as pertaining to one of the other classifications should be classified as adjustments. The utility may have schedules in its annual financial statements titled "Plant in Service" or "Changes in Utility Plant in Service." These schedules should have columns showing plant in service at the beginning of the year, additions, retirements, transfers, and adjustments by plant account. Material adjustments should be reviewed to determine their compliance with accepted accounting practices. The year that the equipment related to the adjustments was placed in service should be determined so that it can be included in the depreciation study data at the proper vintage. If making adjustments results in negative additions or retirements for a given year, further analysis is necessary before the data are useful. When an adjustment of plant is made, a corresponding adjustment of the depreciation reserve should be made in the same manner as adjustments to reflect transfers of plant.

Balance at Study Date

An age distribution of survivors at the study date is the balance remaining from additions by vintage. Such distributions are used in the determination of age and life factors. Symptoms of illogical and unreliable data include distributions showing negative survivors for vintages; vintage amounts increasing from the previous year's distribution; and, for a given vintage, the proportion of the dollars surviving from the original placements not logically tracking the activity. The presence of negative survivors indicates an input error that should be detected by the analyst upon review of the resulting distribution. For vintages to logically increase through the years, related adjustments and transfers made into the account should be apparent in a review of the activity.

Data inequities make the determination of the average age of the current surviving investments and the life characteristics of the account difficult. Reliance on the computer does not, nor should it, take the place of common sense. The computer will generate results based on the input. If the input has inequities, so will the results of the computer generated analysis.

Initial Balance of Installation

An initial balance of installations is the beginning amount in an account. Companies may not have a consistent account history in a form that will provide additions and retirements by years throughout the entire history of the company. Thus, in many instances when CPRs were established, an initial balance was determined by inventory or appraisal. This balance becomes the starting point of the data to be used in the depreciation study, although series of vintages of various lengths and beginning points may be used by the analyst to look for trends. Subsequent installations should be dated when the investment is placed in service and first subject to depreciation accruals.

Gross Salvage

Gross salvage is the dollar amount received for property retired if sold. If retained, salvage is the material recoverable and chargeable to materials and supplies, or another appropriate account.

Scrap salvage is sometimes received because the retired equipment contains material that has value as a raw material, such as copper conductors. Sources of salvage from sales of used equipment also occur. Vehicles, power operated equipment and meters, for example, are purchased by firms that either refurbish them for resale or use the equipment themselves.

Another source of salvage is reuse of equipment within the utility. The removal of an item of property from service with the expectation that it will be reinstalled poses a special problem in life and salvage analyses. One problem is to determine what life (location or final) is reflected in the accounting data and its relationship to the accounting for salvage. Another problem is to determine what salvage should be used for the equipment returned to inventory. The net book value, market value, or average cost of the existing inventory are among the possibilities. Each has varying characteristics of accuracy and availability. In any case, the analyst should seek to determine the life and net salvage factors that reflect the expected retirement and salvage practices to calculate the depreciation rates.

Salvage is recorded by a credit to the depreciation reserve and a debit to accounts receivable if the item is sold or to the materials and supplies account if it is used within the utility. When property consisting of land (which is not depreciable) and several depreciable plant accounts is sold, it may be necessary to allocate salvage among the accounts. If the proceeds from the sale are significant, as in the case of the sale of a retired power plant, it may be appropriate for an independent appraiser to determine what portion of the proceeds is attributable to the land and what portion is attributable to the equipment. Proceeds that are attributable to land and which exceed its original cost would likely be recorded as capital gains, while proceeds assigned to equipment would be recorded as salvage.

Cost of Removal

This is the cost of demolishing, dismantling, or otherwise removing plant, including the cost of transportation and handling. Cost of removal is essentially labor, although transportation, costs of disposing of wastes, repaving costs, and other items are also includable. For example, costs of removal occur when gas lines are disconnected and the easement is restored to the original condition or when power plants are torn down.

Cost of removal is recorded by a debit to the accumulated depreciation account and a credit to the accounts affected by the removal project. Accounts payable, wages payable, and the materials and supplies accounts are possibilities. The estimation of salvage and cost of removal is discussed in Chapter XI.

Valuation Problems and Special Regulatory Considerations

Cost of Construction

The costs of construction are the expenditures related to placing equipment in service. In accounting for construction costs, the utility charges all direct and indirect costs to the construction work order. When the work is placed in service, these costs are charged to the plant accounts. The following are general definitions taken from specific USOAs. Further detail and explanation should be obtained from other federal and state USOAs.

> **Allowance for funds used during construction** - includes the cost of debt and equity funds used to finance property to be completed in a period longer than one year. Allowances for funds used during construction would be charged to the accounts appropriate for the cost of the property in accordance with the rules of the regulatory agency.

Contract work - amounts paid for work done by other firms, costs incident to the award of contracts, and inspections.

Earnings and expenses during construction - includes revenues earned from the sale of power from generating plants during the construction period and costs of operating the power plant.

Engineering and supervision - includes the pay and expenses of engineers, surveyors, draftsman, inspectors, superintendents and their assistants applicable to construction.

Engineering services - includes amounts paid to others engaged by the utility to plan, design, prepare estimates, supervise, or inspect in connection with construction work.

General administration capitalized - includes the portion of the pay and expenses of the general officers and administrative and general expenses applicable to construction work.

Injuries and damages - includes expenditures or losses in connection with construction work due to injuries to persons and damages to the property of others. Insurance recovered on account of such injuries or damages should be credited to the accounts charged with the costs of the injuries or damages.

Insurance - includes premiums paid or amounts provided or reserved as self-insurance for the protection against loss in connection with construction.

Labor - pay and expenses of utility employees engaged in construction work, including insurance and payroll taxes.

Law expenditures - includes court and legal costs related to construction.

Materials and supplies - this is the purchase price, transportation, storage expenses and cost of fabricated materials from the utility's shop. In determining the cost of material used, allowance should be made for unused material, for material recovered from temporary structures used in performing the work involved, and for discounts allowed and realized in the purchase of material. Construction material that is stolen or rendered unusable due to vandalism should be charged to the applicable plant specific operations expense accounts.

Privileges, permits and rights of way - includes payments for and expenses incurred in securing temporary privileges, permits and rights of way in connection with construction work, such as for the use of private property, streets or highways.

Protection - includes the cost of protecting the company's property from fire or other casualties and the cost of preventing damages to others or the property of others.

Rents - includes amounts paid for the use of construction quarters and office space.

Shop service - includes the portion of the expense of the utility's shop department assignable to construction work.

Special machine service - includes the cost of labor expended, materials and supplies, depreciation and other expenses incurred in the maintenance, operation and use of special and other labor saving devices (other than transportation equipment) such as trenching equipment, cable plows and pole setting trucks, whether owned or rented by the utility. When a construction job requires the purchase of special machines, the cost, less the appraised value at the time of release from the job, shall be included in the cost of construction.

Studies - includes the costs of seismic or environmental studies, for example, that are required by regulatory agencies.

Taxes - includes taxes on physical property (including land) before the facilities are completed for service.

Training costs - initial training costs may be capitalized but subsequent costs are expensed.

Transportation - includes the cost of transporting employees, materials and supplies, tools and other work equipment to and from the construction location. It includes amounts paid to other companies and the cost excluding depreciation of using the company's own motor vehicles or other transportation equipment.[2]

Plant Acquisition Adjustment

When plant constituting an operating unit or system is acquired by purchase, merger, consolidation, liquidation, or otherwise, the cost of acquisition, including expenses incidental thereto properly included in plant should be charged to the plant purchased or sold account.

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[2] Utilities generally record such depreciation in clearing accounts, so some of the cost is charged to construction.

The accounting for the acquisition may be completed by crediting the original cost of plant to the plant purchased or sold account, and concurrently charging the cost to the appropriate plant in service, plant leased to others, plant held for future use, or construction work in progress accounts, as appropriate.

The depreciation and amortization applicable to the original cost of the properties purchased should be charged to the plant purchased or sold account, and concurrently credited to the appropriate account for accumulated provision for depreciation and amortization. The cost to the utility of any property included in nonutility property, should be transferred accordingly. The amount remaining in the plant purchased or sold account, shall then be closed to the plant acquisition adjustments account.

If property acquired in the purchase of an operating unit or system is in such physical condition when acquired that it is necessary to rehabilitate it in order to bring the property up to the standards of the utility, the cost of such work, except replacements, should be accounted for as part of the purchase price of the property.

When any property acquired as an operating unit or system includes duplicate or other plant that will be retired by the accounting utility in the reconstruction of the acquired property or in its consolidation with previously owned property, the proposed accounting for such property should be presented to the regulatory commission.

In connection with the acquisition of plant constituting an operating unit or system, the utility should procure the existing records relating to the property acquired.

When plant constituting an operating unit or system is sold, conveyed, or transferred to another by sale, merger, consolidation or otherwise, the book cost of the property sold or transferred to another should be credited to the appropriate plant accounts, including amounts carried in the plant acquisition adjustment account. The amounts carried in the accounts for accumulated provision for depreciation and amortization and as customer advances for construction, should be charged to such accounts and contra entries made to the plant purchased or sold account. Unless otherwise ordered by the regulatory commission, the difference, if any, between (a) the net amount of debits and credits and (b) the consideration received for the property (less commissions and other expenses of making the sale) should be treated as a gain or loss on disposition of property.

Contributed Property

The plant accounts should not include the cost or other value of plant contributed to the company. Contributions in the form of money or its equivalent toward the construction of plant should be credited to the accounts charged with the cost of such construction. When assembling cost data in work orders for posting to plant ledgers of accounts, plant constructed from contributions of cash or its equivalent should be shown as a reduction to gross plant constructed. The accumulated gross costs of plant accumulated in the work order should be recorded as a debit in the plant ledger of accounts along with the related amount of contributions concurrently being recorded as a credit.

There may be instances where the contribution is recorded as a debit to plant in service and a credit to the contribution-in-aid-of-construction account and the latter account is not closed to plant in service. There should then be an amortization of the plant in service amount and the contribution in aid of construction amount over the periods of time that the contributed plant is in use. This will prevent recovery of the plant amount again through inclusion of the depreciation expense in service rates and also prevent the contribution in aid of construction from remaining on the books indefinitely.

Customer Advances for Construction

This account includes advances by customers for construction which are to be refunded either wholly or in part. When a customer is refunded the entire amount to which he is entitled according to the agreement or rule under which the advance was made, the balance, if any, remaining in this account should be credited to the respective plant account.

There is also the situation of reimbursements by customers or others to compensate the utility for rearranging or moving equipment. This may be done to permit construction of a building or widening of a road. The monies received should be recorded as offsets to the costs incurred.

Jointly Owned Property

With respect to jointly owned property, there is shown in the continuing property record or supplemental records:

1. The identity of all owners, and
2. The percentage owned by the accounting company.

When regulated plant is constructed under arrangements for joint ownership, the amount received by the constructing company from the other joint owner or owners is credited so as to be a reduction of the gross cost of the plant.

When a sale of a part interest in regulated plant is made, the fractional interest sold is to be treated as a retirement and the amount received is to be treated as salvage. The continuing property record or records supplemental thereto is maintained to separately identify retirements of this nature from physical retirements of jointly owned plant.

If jointly owned regulated property is substantial in relation to the total of the same kind of regulated property owned wholly by the company, such jointly owned regulated property may be appropriately segregated in the continuing property record. The contract providing for the operation, retirement, and removal of the jointly owned property should be reviewed by the depreciation analyst to determine how these responsibilities are assigned to the owners, as there could be implications for depreciation rates.

Capitalized Spare Parts

In order for the utility to continue to provide reliable service, it is necessary that large components be kept on hand in case that plant in service breaks down. For example, if a turbine rotor needs to be replaced, the time to manufacture and ship such a large, specialized component may be months. During this period, the generating plant may have to shut down if a spare rotor is not on hand. Such necessary and costly spare parts may be permitted to be capitalized and their cost allocated over the service life of the related plant account.

Plant Held for Future Use

This is plant equipment or land which the utility has acquired with the intent of using it to provide service to customers at some future date. There should be a definite plan for its use and a time period when the use will likely begin.

Materials and supplies, meters and transformers held in reserve, and normal spare capacity of plant in service are not included in this account.

Leased Plant (from the FERC USOA for Electric Utilities)

Criteria for Classifying Leases

Depending on the rules of the regulatory commission, if at its inception a lease meets one or more of the following criteria, the lease shall be classified as a capital lease.

Otherwise, it shall be classified as an operating lease.

1. The lease transfers ownership of the property to the lessee by the end of the lease term.

2. The lease contains a bargain purchase option.

3. The lease term is equal to 75 percent or more of the estimated economic life of the leased property. However, if the beginning of the lease term falls within the last 25 percent of the total estimated economic life of the leased property, including earlier years of use, this criterion shall not be used for purposes of classifying the lease.

4. The present value at the beginning of the lease term of the minimum lease payments, excluding that portion of the payments representing executory costs such as insurance, maintenance, and taxes to be paid by the lessor, including any profit thereon, equals or exceeds 90 percent of the excess of the fair value of the leased property to the lessor at the inception of the

> lease over any related investment tax credit retained by the lessor and expected to be realized by the lessor. However, if the beginning of the lease term falls within the last 25 percent of the total estimated economic life of the leased property, including earlier years of use, this criterion shall not be used for purposes of classifying the lease payments using its incremental borrowing rate, unless (a) it is practicable for the utility to learn the implicit rate computed by the lessor, and (b) the implicit rate computed by the lessor is less than the lessee's incremental borrowing rate. If both of those conditions are met, the lessee uses the implicit rate.

Changes in the terms and circumstances of the lease should cause a review of the existing classification. Changes in estimates that do not cause a change in the lease document (for example, changes in estimates of the economic life or of the residual value of the lease property) or changes in circumstances (for example, default by the lessee), should not give rise to a new classification of a lease for accounting purposes.

Accounting for Leases

All leases are classified as either capital or operating leases in accordance with the above criteria.

The utility shall record a capital lease as an asset in the Property under capital leases account, the Nuclear fuel under capital leases account, or Nonutility property, as appropriate, and as a credit in an Obligation under capital leases—noncurrent or current—at an amount equal to the present value at the beginning of the lease term of minimum lease payments during the lease term, excluding that portion of the payments representing executory costs such as insurance, maintenance, and taxes to be paid by the lessor, together with any profit thereon. However, if the amount so determined exceeds the fair value of the leased property at the inception of the lease, the amount recorded as an asset and obligation shall be at fair value.

Rental payments on all leases shall be charged to rent expense, fuel expense, construction work in progress, or other appropriate accounts as they become payable.

For a capital lease, for each period during the lease term, the amounts recorded for the asset and obligation shall be reduced by an amount equal to the portion of each lease payment that would have been allocated to the reduction of the obligation, if the payment had been treated as a payment on an installment obligation (liability), and allocated between interest expense and a reduction of the obligation so as to produce a constant periodic rate of interest on the remaining balance.

Where additions or replacements are made the cost shall be spread over the period of usefulness to the lessee.

The diminution in usefulness, service capacity, or service life that occurs between the date of the lease and the date of its termination should be reflected in the books of the lessor during that period.

Accounting for Additions

Capital Additions

Capital additions involve the placement of new facilities or the betterment of existing facilities expected to last more than one year. Additions should be accounted for by adding the cost to the appropriate plant account. When plant constituting an operating system is acquired from another utility, the accounting used should be the accounting required by the regulatory commission.

When a retirement is made from the plant account, with or without replacement, the book cost of the retirement unit should be credited to the plant account in which it is included. If the retirement unit is of a depreciable class, the book cost of the unit retired and credited to plant is charged to accumulated depreciation applicable to such property. The cost of removal and the salvage are also charged or credited, as appropriate, to the accumulated depreciation account. This is the group depreciation procedure.

It is possible to maintain the accumulated depreciation on a primary account and subaccount basis. Then straight-line remaining life depreciation rates can be calculated for each primary account and subaccount. However, another practice is to keep the reserve on a functional group basis. Then if straight line remaining life depreciation rates by account are to be calculated, it is first necessary to allocate the functional group reserve to the accounts in the group.

Betterments or Improvements

These terms are used to describe additions to existing plant which are intended to provide increased or improved services. Minor betterments may be expensed, but major ones require removal of the book cost of the old asset and reduction of the related accumulated depreciation. Examples of the latter may be replacement of essentially all of a heating or lighting system.

Rearrangements

Rearrangements involve the movement of equipment and its reinstallation. If there are reinstallation costs involved, the original installation costs should be retired and the new costs capitalized. However, if cradle-to-grave accounting is used, such costs would be expensed.

Capitalizing Verses Expensing

Change in the Capitalization Threshold

Equipment costing less than a specific dollar amount and/or having a life of less than one year is expensed in the year purchased. This reduces the need for the records and periodic inventories that would otherwise be necessary for items of small value.

If the capitalization threshold is increased, the property records could be reviewed to determine if items below the increased threshold should be retired. If retired, the unrecovered investment may be amortized. If it is decided that such items should remain in the CPR, their physical retirement may never be reported unless field personnel are trained to report these retirements. Underreporting of retirements would give misleading indications of a longer average service life for this equipment.

Computer Software

The use of computers for functions such as network monitoring and control, system mapping, process control, customer billing and information systems is an important part of the utility business. The development or acquisition costs of the associated computer programs and the labor to transform and enter data into a form for computers to use can be substantial. For example, a utility may spend substantial sums over several years to convert the information on its distribution plant maps to an automatic mapping system. Corporate financial models and long-term planning models are also costly. The accounting for costs such as these should be consistent with the rules and interpretations of the regulatory agency. One approach is to capitalize the initial costs along with the computer and expense all subsequent costs. Another approach is to expense the costs of the data and software if they are immaterial and recurring. If the costs are material and expected to provide benefits for more than one year, they may be capitalized as miscellaneous intangible plant or recorded as a deferred debit and amortized over a period of years.

CHAPTER IV

DEPRECIATION ACCOUNTING

The Basic Accounting Concept

Basically, depreciation accounting is the process of charging the book cost (generally stated as original cost in utility accounting) of depreciable property, adjusted for net salvage value, to operations over its useful life. The accounting principle upon which depreciation is based is called the matching principle. Under the matching principle, expenses are assigned to accounting periods in a manner that matches expenses with revenues. Because depreciable assets are acquired for use in the earnings process over a period of years, the matching principle requires that a portion of the cost of the assets be charged to depreciation expense each period to properly measure net income. When depreciation expense is recorded, the net book value of the property is simultaneously reduced by an equal amount.

Why operational assets give rise to an expense each accounting period can be best understood if the investment in an operational asset is viewed as a prepaid expense. An operational asset is acquired for use over a number of years. Moreover, it is known at the outset that the asset has a finite useful life, and that the value of the asset will be substantially diminished at the end of its useful life. The decline in the value of the asset during its useful life is an expense of operations related to the entire period. Depreciation accounting estimates that expense based on life and salvage estimates and allocates a portion of the expense to each accounting period.

It should be emphasized that the primary objective of depreciation accounting is the allocation of cost to expense rather than valuation of the asset. Although the net book value of the asset is reduced in recording depreciation, this merely recognizes that a portion of the asset cost has been charged off to expense. The resulting net book value is not intended to reflect the current market value of the property. The net book value is, however, an important measure of the adequacy of depreciation estimates.

Generally accepted accounting does not require any specific method of determining depreciation expense. It only requires that the method used to allocate the cost of assets to accounting periods be systematic and rational. Thus, a variety of methods are encountered in accounting practice. Depreciation may be computed on individual assets or on groups of assets. Also, it may be computed on a straight-line basis by which equal amounts are charged to each period or on an accelerated basis by which greater expense is assigned to the early years of an asset's life rather than to the later years. Alternatively, unit of production depreciation is based on the ratio of the number of units produced during the accounting period to the expected total production. The product of this ratio and the cost of the asset yields the depreciation expense. Depending on the circumstances in each case, all of these methods will produce acceptable results and will meet the general test of being systematic and rational.

In utility accounting, depreciation is usually computed on a straight-line, group method. The asset groupings and the depreciation rates applied to each group are often prescribed periodically or reviewed by a regulatory commission. The depreciation rates are related to the underlying asset life and salvage data to insure that they remain consistent with actual operations.

Depreciation, Depletion, and Amortization-Differences

With regard to operational assets, the terms depreciation, depletion, and amortization all relate to the process of matching the consumption of property with revenues through periodic charges to expense. The terms are not synonymous, however. The primary distinction between the terms is the types of assets to which they relate. Depreciation relates to the expiration of tangible fixed assets such as buildings and equipment. Depletion relates to the extraction or consumption in operations of natural resources such as timber tracts, oil wells, and mineral deposits. Amortization is the term used to describe the periodic allocation of costs reflecting the expiration of intangible assets such as patents, copyrights, and leaseholds. Amortization is also used as a general term to describe other periodic allocations in accounting as discussed below.

In addition to the types of assets involved, depreciation, depletion, and amortization may be distinguished somewhat by the manner in which periodic charges are determined. As noted, a variety of methods are used to compute the periodic charges of depreciation expense. This same latitude does not generally extend to depletion and amortization. Because depletion relates to the extraction of natural resources, it is generally determined by the unit of production method. A rate per unit of output is developed which is applied to the number of units produced during the accounting period to arrive at the cost of depletion for the period. Amortization is generally determined on a straight-line basis. The cost to be amortized is divided by the number of periods of use to determine the amount to be charged equally to each period.

To the extent possible, the distinction between depreciation, depletion, and amortization should be recognized in accounting for operational assets, and each should be computed and recorded separately in the accounts. It should be noted, however, that the term amortization is a general term used in accounting to describe various types of periodic apportionment, some of which do not even involve assets, such as the amortization of debt discounts. Because of the general nature of the term, amortization is sometimes used in reference to depreciation. Moreover, amortization is commonly used to describe the periodic allocation of costs of tangible fixed assets in special circumstances such as allocations over a period of time not related to useful life. Where tangible property is dependent upon the period of exhaustion of natural resources, as, for example, a branch line leading to timber or mines, the process of accounting for the consumption of plant is often termed "amortization" rather than "depreciation."

In practice, depletion and depreciation are sometimes treated jointly in the accounts with a consequent disappearance of, or disregard for, the technical distinction between the terms. A single factor is applied to the aggregate of a number of accounts that include costs of extractive rights, construction, and other cost elements. Such a factor often represents the ratio of the actual number of units produced during the period to the estimated number of units available for extraction.

For federal income tax purposes, depletion may be computed using the statutory or percentage method permitted by the Internal Revenue Code rather than the procedures discussed above which are used for financial and cost accounting purposes. The taxpayer computes depletion by the statutory or percentage method and by the accounting method as discussed above and claims the larger amount as a deduction. Statutory depletion is based on a percentage of revenues and is completely independent of the cost of the property. Thus, the total depletion charges allowed may exceed the original cost of the resource. The percentage deduction allowed statutory depletion varies depending on the resource involved. Percentage rates are specified for various natural resources.

Recording Depreciation

Most public utilities are required to follow uniform systems of accounts prescribed by regulatory agencies. These uniform systems generally prescribe the chart of accounts and provide specific instructions, including the accounting for depreciation. For example, the USOA for Telecommunications Companies prescribed by the FCC provides the following instructions for depreciation (*Code of Federal Regulations CFR*, see Section 32.2000(g)):

> (g) Depreciation Accounting - (1) Computation of depreciation rates. (i) Unless otherwise provided by the Commission, either through prior approval or upon prescription by the Commission, depreciation percentage rates shall be computed in conformity with a group plan of accounting for depreciation and shall be such that the loss in service value of the property, except for losses excluded under the definition of depreciation, may be distributed under the straight-line method during the service life of property. (ii) In the event any composite percentage rate becomes no longer applicable, revised composite percentage rates shall be computed in accordance with paragraph (g)(1)(i) of this section. (iii) The company shall keep such records of property and property retirements as will allow the determination of the service life of property which has been retired, or facilitate the determination of service life indications by mortality, turnover, or other appropriate methods. Such records will also allow the determination of the percentage of salvage value and cost of removal for property retired from each class of depreciable plant.
>
> (2) Depreciation Charges. (i) A separate annual percentage rate for each depreciation category of telecommunications plant shall be used in computing depreciation charges. (ii) Companies, upon receiving prior approval from this Commission, or, upon prescription by this Commission, shall apply such depreciation rate, except where provisions of paragraph (g)(2)(iv) of this section apply, as will ratably distribute on a straight line basis the difference between the net book cost of a class or subclass of plant and its estimated net salvage during the known or estimated remaining service life of the plant. (iii) Charges for currently accruing depreciation shall be made monthly to the appropriate depreciation accounts, and corresponding credits shall be made to the appropriate depreciation reserve accounts. Current monthly charges shall normally be

> computed by the application of one-twelfth of the annual depreciation rate to the monthly average balance of the associated category of plant. The average monthly balance shall be computed using the balance as of the first and last days of the current month. (iv) In certain circumstances and upon prior approval of this Commission, monthly charges may be determined in total or in part through the use of other methods whereby selected plant balances or portions thereof are ratably distributed over periods prescribed by this Commission. Such circumstances could include but not be limited to factors such as the existence of reserve deficiencies or surpluses, types of plant that will be completely retired in the near future, and changes in the accounting for plant. Where alternative methods have been used in accordance with this subparagraph, such amounts shall be applied separately or in combination with rates determined in accordance with paragraph (g)(2)(ii) of this section.

Naturally, only certain segments of the telephone industry operate under the USOA prescribed by the FCC, but the foregoing excerpt contains many of the generally accepted elements that enter into the computation of depreciation charges. Depreciation expense is recorded by debiting a depreciation expense account and making a corresponding credit to reduce the net book value of the related asset. The credit, however, is not recorded in the asset account. Instead, the credit is recorded in a contra asset account which is deducted from the cost recorded in the asset account to determine the net book value. In utility accounting, this contra asset account has been traditionally referred to as the depreciation reserve.

Although the term depreciation reserve is widely used in utility accounting to describe the contra asset for depreciation, the accounting profession has had a long-standing recommendation that the term reserve not be used in that way. Accounting Terminology Bulletin #1, which was issued by the American Institute of Certified Public Accountants (AICPA) in 1953, recommended that the term "reserve" not be used in reference to contra asset accounts. In fact, it recommended that the term "reserve" not be used in accounting at all except to describe an appropriation of retained earnings. The Bulletin further recommended that the contra asset account for depreciation be referred to as accumulated depreciation. Although utility accounting has been slow to respond to this recommendation, the FCC's USOA for Telecommunications Companies, effective January 1, 1988, changed the name of the contra asset account from Depreciation Reserve to Accumulated Depreciation. Because of the long-standing use of the term "depreciation reserve" in utility accounting, that term is used interchangeably with "accumulated depreciation" in this book.

Accounting for depreciable assets involves the following steps:

1. Recording acquisition of assets,
2. Recording periodic charges for depreciation with a corresponding credit to accumulated depreciation, and
3. Recording retirement of assets including salvage received and cost of removal.

To illustrate the accounting process for depreciation, several simplified journal entries are presented below. These entries are based on the following assumptions:

a. Plant costing $100,000 is acquired and placed in service.
The estimated life is 10 years and the estimated net salvage is $10,000.

b. Depreciation Expense is recorded on a straight-line basis. The annual expense is $9,000 computed as follows:

$$\frac{\$100{,}000 \text{ (cost)} - \$10{,}000 \text{ (net salvage)}}{10 \text{ years (life)}} = \$9{,}000 \text{ per year}$$

In practice, this would most likely be recorded on a monthly basis.

c. Plant is retired at the end of 10 years.

d. Cost of removal upon retirement from service is $5,000.

e. Cash received on retirement is $15,000.

Based on these data, the following entries would be made.

Accounts	Debit	Credit
Plant	$100,000	
Cash		$100,000
To record plant assets acquired and placed in service at a cost of $100,000.		
Depreciation Expense	$9,000	
Accumulated Depreciation		$9,000
To record annual depreciation on plant in service. (This entry would be made each year for 10 years.)		
Accumulated Depreciation	$100,000	
Plant		$100,000
To record the retirement of plant with an original cost of $100,000.		
Accumulated Depreciation	$5,000	
Cash		$5,000
To record cost of removal of retired Plant.		
Cash	$15,000	
Accumulated Depreciation		$15,000
To record cash received from sale of retired plant.		

This simplified example illustrates the basic accounting entries involved in recording depreciation. The estimated life and salvage factors used to compute depreciation and the actual life and salvage were the same; however, this rarely occurs in practice.

Comparison of Group and Unit Depreciation

The difference in the entries for group and unit depreciation is in the recording of retirements. Because the estimated life and salvage factors used to compute depreciation and the actual amounts reflected in the retirement entries were the same, the entries in the preceding illustration would be the same whether the depreciation was computed on a group basis or a unit basis. If the actual life and salvage were different from the estimates, the retirement entries would be different for assets depreciated on a unit basis than for assets depreciated on a group basis.

Under unit depreciation, life and salvage is estimated for individual assets and depreciation is recorded on that basis. Because of this, the accumulated depreciation and net book value (i.e., cost less accumulated depreciation) for individual assets can be determined at any time. When an asset is retired, therefore, the net book value is compared to the net salvage received (net salvage is the proceeds received from the disposition of the retired asset less cost of removal). If net salvage exceeds net book value, the retirement results in a gain, and if net salvage is less than net book value, the retirement results in a loss. Gains and losses for retirement of assets are recorded in the period that the retirement occurs.

Under group depreciation, no gain or loss is recognized for retirement of individual assets. Upon retirement of an asset from the group, the cost of the asset is debited to the accumulated depreciation account and credited to the asset account. Any gross salvage received for the retired asset is credited to the accumulated depreciation account and any cost of removal is debited to the accumulated depreciation account. Under group depreciation, since the accumulated depreciation relates to the entire group rather than to specific assets within the group, no gain or loss is recognized. This assumes that the group depreciation rate is accurate for the group as a whole and that the cost of the retired asset, net of gross salvage and cost of removal, is being fully provided for in the accumulated depreciation account.

Clearing Accounts

Clearing accounts are special accounts which serve to accumulate costs temporarily until the costs can be allocated to other related accounts. For example, if the accounting objective is to assign all motor vehicle expenses to functions and activities supported by the use of motor vehicles, the costs associated with motor vehicles are first accumulated in a motor vehicle expense clearing account and then allocated to the functions and activities supported by motor vehicles based on a usage factor. A motor vehicle expense clearing account is used because the expenses associated with motor vehicles cannot be assigned to the final accounts at the time incurred. For example, if motor vehicles support both the maintenance of existing assets and construction of new ones, part of the motor vehicle costs would be cleared to maintenance expense and part would be capitalized as a cost of the new assets being constructed. Various types of costs may be recorded in the same clearing account. For example, labor, insurance, fuel, and depreciation may all be recorded in the motor vehicle expense clearing account. When these costs are cleared to other accounts, they are cleared as motor vehicle expense and the individual cost components that comprise motor vehicle expense lose their identity.

The use of clearing accounts is of significance to depreciation accounting in two respects. First, not all depreciation expense is separately recorded and identified in depreciation expense accounts; it may lose its identity in the clearance process. Second, not all depreciation is charged to expense in the year that it is recorded; it may be recapitalized in the clearance process. Thus, when a portion of depreciation is charged to clearing accounts, the depreciation expense accounts do not reflect the entire depreciation accrual for the period. To determine the total depreciation accrual for the period, therefore, it may be necessary to analyze the debits and credits made to the accumulated depreciation account.

CHAPTER V

COMPUTING DEPRECIATION

Previous chapters have established that depreciation is an element of cost of service, that a charge to expense is made each accounting period, and that under practically all systems of accounts, the contra entry is a credit to the depreciation reserve. This chapter deals with methods, procedures, and techniques used in computing the depreciation charge. Method refers to the pattern of depreciation in relation to the accounting periods, or in some cases, usage. Procedure generally refers to the grouping of assets or the form of the depreciation base. Technique references the portion of the average life used in the calculation of depreciation.

It is assumed that a depreciation base or series of bases has been selected. In keeping with the discussion of concepts in Chapter II, the objective of computing depreciation is to allocate the cost or depreciation base over the property's service life by charging a measure of the consumption of plant taking place to each accounting period. The different depreciation methods are designed to achieve this objective. Some estimate of future conditions is inherent in all methods, and provision for review and adjustment of these estimates may influence the selection of a method of computation. The subject of periodic review is discussed in Chapter XIII.

The Measurement of Asset Consumption

Given the objective of allocating an asset's cost over its service life, it becomes almost axiomatic that the life—either average service life, remaining life, or some related measure—will enter into the computation of depreciation. Consider further the charging of a measure of consumption to each accounting period, and age becomes, a priori, a part of the computation. The dominance of the so-called age-life plans today stems from these premises. In Chapter I it was noted that many earlier methods utilized other plans. A review of the age-life methods in general with some of the other surviving methods follows.

Age-Life Methods - The Depreciation Rate

Common to all age-life methods is an estimate of service life and an apportionment of expense to each year or accounting period so that the total cost is recovered over the life of the asset. Generally the depreciation base adjusted for any estimated net salvage is used as the total sum to be recovered. In straight-line unit accounting, the estimated life is used as a divisor to directly determine the dollars to charge as expense. In group accounting and for mass property accounts, the charge to expense is computed by first determining a depreciation rate. It is common practice to express this as an annual percent. To determine expense, the rate is then applied to the depreciation base each year or accounting period. As additions and retirements take place, the rate is applied to the revised balances. Adjustments to the rate are made to conform to shorter accounting periods. For example, with monthly accounting, one-twelfth the annual rate may be applied to each month's balance.

The age-life methods take several forms. In the simple straight-line form, the rate is held constant and changes are made only when revised estimates of life or net salvage occur. In the sinking fund method, an annuity rate is used and interest on the accumulation of depreciation is added. In the declining balance method, a constant rate is used but it is applied to the net plant. In the sum-of-the-years-digits method, the rate varies with age resulting in recording more expense in early life and less in later life.

In all these methods, two estimates are required, one of service life and the other of net salvage, each of which is the subject of a subsequent chapter. With these estimates plus a judgment selection of the precise method to be used, it is apparent that the cost assignable to each accounting period is also an estimate. The estimate can be improved by using objective statistical studies, comparative analysis with like plant, and periodic reviews that take into consideration both historical experience and, to the extent possible, future expected circumstances. All these aid in producing reasonably accurate results, particularly where large numbers of units of plant are involved. Because the end result is necessarily still an estimate of the future, some form of periodic review has become accepted practice in most depreciation work. Factors causing retirement do change, and "accurate" estimates made at one time may no longer hold true a few years later.

Because reasonable estimates at any time are attainable, and age-life methods directly meet the depreciation objective, age-life methods are favored by all accounting, regulatory, and tax depreciation plans. Departures from age-life methods require specific justification, such as extraordinary obsolescence or consumption not related to age.

The Unit of Production Method

The unit of production method is similar to age-life methods except that in place of an estimate of life, total service in terms of units of production is estimated. For example, miles of operation, hours of operation, or unit volume of throughput have been used to estimate useful life. Where plant may stand idle for periods of time and then be brought into productive operation for varying stretches, the unit of production method may offer a more accurate measure of depreciation. The crucial tests are whether total service can be more accurately forecast in production units or in years of life span and whether consumption is entirely unrelated to age or is reasonably related to age.

In the transportation field, this method has been applied using miles of operation, ton-miles hauled, or hours of operation. Some gas pipeline companies owning gas producing property employ the unit of production method to depreciate certain classes of property. This unit rate is expressed as cents per thousand cubic feet (Mcf) and is generally computed by dividing the unrecovered investment less estimated net salvage by the estimated recoverable Mcf of gas reserves. In both these applications, it is argued that the total production can be more accurately estimated than the service life. This was probably more true in the past. Today, rapid changes in technology often cause retirement even though the equipment is still functional and still has a substantial remaining production life. An example of this may be the replacement of analog technology with digital technology.

In some applications of the unit of production method of depreciation, estimates of total production are obtained by first estimating the service life and then applying average usage data to get the total production estimate. If such a procedure is necessary, it only underscores the advantage of the age-life method.

Inherent in the unit of production method is an assumption that each unit of production, however measured, should bear the same depreciation expense. This may not always be true. For example, service at times of peak load may involve more physical depreciation than at off-peak periods.

During periods of low production, such as a business recession, or when demand for services is declining, the unit of production method tends to find more favor, because it may moderate heavy fixed charges to conform to services rendered and revenues received. The unit of production method is valid if the primary cause of depreciation is wear and tear. If, as is generally true today, most plant also depreciates because of changes in the art or technology, changes in public requirements, obsolescence and other external forces, the unit of production method loses validity. Additionally, while depreciation is generally regarded as a "fixed" charge or, as some express it, a "cost of ownership," the unit of production method tends to relate depreciation to the category of "variable" charges related to the amount of commodity furnished or the usage.

The practical basis for the age-life, fixed charge approach is illustrated by the example of a water or gas main. Is depreciation of the main taking place because of the volume of flow through it? Or, is it taking place because it sits in soil which acts on its exterior? Or, is it taking place because it is in the path of a new express highway soon to be built? Obviously, causes independent of units of production dominate in retirements of typical mains. Similar examples may be found in other types of utility plant. They illustrate another reason why the unit of production method has not been used much in the utility industry.

Appraisal and Good as New Methods

As stated in Chapter I, one early refinement to lump-sum write-downs of capital was that of making a periodic inventory and appraisal and determining the loss of appraised value. This method survives in isolated utility applications which include (1) an initial study preparatory to starting more orthodox depreciation accounting; (2) a measure of depreciation with a reproduction cost rate base; (3) a test of value in contrast to cost at a time of sale or transfer; and (4) a criterion to aid in determining just compensation. In the more modern applications, the loss in appraised value is more often accounted for as a reserve for depreciation rather than as a direct write-down of the plant assets. Economic depreciation is closely related to the appraisal method. Rather than apply a wide range of engineering and market-place factors for appraisals, economic depreciation preserves the original cost but adjusts for current or constant dollars. In effect, economic depreciation is an appraisal and an adjustment of depreciation based on the general change in purchasing power of the dollar.[1]

The application of appraisal methods, particularly in valuations for sales or just compensation, has brought with it occasional arguments that operating utility plant that is well and regularly maintained has little or no depreciation as long as its productive capacity is close to its original capacity. This premise is termed the "good as new technique" for measuring depreciation. Outside of a just compensation proceeding, it is almost never advanced, and in such a proceeding its acceptance is limited. It ignores the basic objective of charging a reasonable measure of the ultimate consumption of plant to each period throughout its service life.

Full application of the appraisal method places depreciation on a value rather than a cost concept, and to this extent it may violate the objective of allocating the cost of plant during its useful life. The technique is also cumbersome and involves a great deal of effort in most applications. Usually the result of depreciation in an appraisal is spoken of as a "condition percent" and derivation of this percent involves straight-line, sinking fund, or other age-life formulae applied collectively to each appraisal unit.

In proposals for economic depreciation, straight-line depreciation is usually retained. In its simplest form, one would merely restate the plant accounts in terms of current dollars and apply the regularly used depreciation rate. Assuming gradual dollar inflation, this would result in an increase in theoretical plant assets and a dollar increase in depreciation expense each year for otherwise stable plant. Economic depreciation modifies the objective of allocating cost during useful life by redefining cost. As noted above, the increase in plant assets would be theoretical under most proposals, inasmuch as no overall gain would result if the plant assets were actually increased. In the normal process of determining retirement unit costs, the inflated plant base would result in inflated retirement unit costs so that when an item was retired it would drain the reserve of all the extra accruals. If accruals were made on a current value basis and retirements on an original cost basis, and assuming gradual inflation, the reserve ratio (reserve as a percent of plant) would be higher using economic depreciation than would be derived on an original cost basis. This is because older units have higher reserves and receive large current cost adjustments so that the reserve as a percent of plant increases. The impracticability of this method is that the reserve becomes increasingly out of proportion as the plant ages, so that, when an entire category of plant is finally retired, a substantial reserve remains on the books to be deducted in determining rate base forever after.

Actually, the proponents of the economic depreciation concept would not credit the excess depreciation accruals to the depreciation reserve but rather to a special capital adjustment account

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[1] Economic Depreciation is defined as "...the cost of depreciable assets consumed during a year, expressed in terms of purchasing power of the original investment. Economic depreciation can be calculated by adjusting either the actual-cost depreciation base or the actual-cost depreciation accrual so as to produce an annual depreciation accrual reflecting changes in the value of money brought about by price-level changes." (Paul J. Garfield, Ph.D. and Wallace F. Lovejoy, Ph.D., *Public Utility Economics,* (Prentice Hall, Inc. 1964)).

During the 1980s, the term "economic depreciation" was attached to the theory that measures depreciation by the change in present value of an asset's remaining cash flows.

which would enrich equity. In times of deflation, the debit amount would presumably be applied against retained earnings.

Retirement and Replacement Methods

These methods, discussed in detail in Chapter I, also fail to meet the depreciation objective. Their use today is confined to a few isolated applications. One application is in connection with extraordinary obsolescence, abandoned, or superseded plant. Another application is for bond indentures.

When an unusual retirement occurs or when one type of plant is to be totally replaced, such as manufactured gas equipment or electronic analog central office equipment, a form of retirement and replacement accounting may be used. Such circumstances usually involve an unacceptably large deduction from the depreciation reserve and are corrected by amortizing the retirement over a period of years or by increasing depreciation on the new plant for a time to cover the loss. If the anticipated retirement is sufficiently far in the future, an alternative would be to amortize the unrecovered cost prior to retirement on a schedule that takes into account the projected retirement date.

The refinement of the replacement method, whereby a fixed percent of revenue is set aside for depreciation, is still applicable to some bond indentures. Here the application is not strictly a method of computing depreciation but rather a requirement that the amount computed shall at least equal a certain minimum amount. The more common bonding test today, which requires net operating income to be at least twice the annual interest expense, indirectly places a similar floor on the amount of depreciation to be charged, thereby ensuring that retirements and replacements will be provided for. Similar to the original retirement and replacement methods, these tests give recognition to depreciation, but they are not equivalent nor do they fully apply the basic objective of computing depreciation.

Summary

A logical basis for the age-life methods of depreciation is the fact that depreciable property has a finite life. It is universally accepted that the value and usefulness of depreciable property relates in some manner to its age or the passage of time. This is particularly true of the physical plant invested by public utilities and industrial manufacturers to produce their products and services. As a corollary, providing for the depreciation of those assets should be related to age. Although a number of depreciation methods that do not directly consider the age of property were discussed, they are of rather limited use in public utility practice, where the age-life methods dominate.

Age-Life Methods

The more commonly used methods for computing depreciation are oriented to spreading depreciation charges over the service life or an arbitrary service period so as to reflect an assumed consumption with time (the age-life methods). The various age-life methods are presented below in accordance with the manner in which they spread depreciation expense over the life of property.

The Straight-Line Method

The straight-line method ratably charges a like amount to each accounting period over the service life of a plant item or plant group. Thus, it directly meets the depreciation objective, which perhaps accounts for its wide acceptance in utility practice. The basic formula is:

$$\text{Annual Depreciation Accrual} = \frac{\text{Depreciable Cost}}{\text{Service Life}} \qquad (1)$$

where Depreciable Cost is original or gross plant cost less estimated net salvage.
In actual practice a depreciation rate is applied to the book cost of plant.

The straight-line method is sometimes spoken of as the method of equal annual depreciation charges. For item or unit accounting, this is true if the service life and net salvage are correctly estimated from the beginning of placement in service. However, because of changes in depreciation rates, which reflect changing conditions of service and causes of retirement during the service life, the equal annual charges are not usually made even for unit depreciation. With group properties, equal annual charges seldom occur because, although the rate may be constant, the rate is applied to a changing plant balance by virtue of retirements and additions. Thus, the straight-line method is best described as the method of constant rate applied to the book cost of plant in service between depreciation review periods.

The following formula is used to determine the depreciation rate to be applied to the original or gross plant cost:

$$d = \frac{100 - c}{L} \qquad (2)$$

where d is the depreciation rate in percent
where c is the estimated average net salvage in percent
where L is the estimated average service life

The formula requires two basic estimates—service life and anticipated net salvage. With group properties, care must be exercised to be sure the life and net salvage estimates reflect averages for the entire group to which the rate will be applied. This is because the estimates are often based on consideration of the more prominent items within the account. The selection of depreciation categories discussed in Chapter III and the methods of weighting discussed in Chapter IX are factors to consider. With estimates related to an account or group of accounts, the straight-line formula immediately yields rates and accruals without further factoring or allowing for interest or other adjustments applicable to other age-life methods.

Accelerated Methods

Depreciation methods are classified as "accelerated" if they result in higher depreciation accruals in the early years of service life as compared to the straight-line method. Certain methods of accelerated depreciation received increased attention because they were permitted by the Internal Revenue Code, enacted in 1954. The "Sum-of-the-Years-Digits" and the "Declining Balance" methods are both purely mathematical approaches designed for increasing accruals in the early years of service life. They have not been generally accepted as methods for accruing depreciation on utility properties for regulatory purposes; they are of interest because of their use by some utilities for Federal and state income tax purposes. Unlike the straight-line method which is discussed in subsequent chapters, the following accelerated methods are not used for regulatory purposes.

Declining Balance Method

In this method a rate higher than the straight-line rate is applied to the net plant balance rather than the gross plant balance. Prior years' accruals are deducted each year to yield the "declining balance." The declining balance method is generally tied to the straight-line rate by some arbitrary factor such as 1-1/2 or 2. The rate for the double declining balance method is:

$$d_2 = 2\left[100 - \frac{c}{L}\right] \qquad (3)$$

where L is the service life
where c is the percent net salvage

The annual accrual is determined according to the following formula:

$$D_2=d_2(B-U) \tag{4}$$

where B is the gross depreciable plant
where U is the depreciation reserve

The declining balance computations require the same basic estimates of salvage value and service life required in the straight-line method. In addition, the reserve and the net balance must be maintained by account or depreciation category.

In all of the declining balance applications, the amount charged to expense each year for a single unit or group of plant assets follows an exponential curve that declines with age. The curve is asymptotic to zero, so that unless there is positive net salvage, the cost of plant is never fully allocated. Salvage is usually ignored in the double rate formula for this reason. Also, at some point in the latter portion of the life, applications of the method often include either arbitrary balancing charges or a shift back to a straight-line remaining life plan.

Where estimates of service life are subject to wide possible error, the declining balance method has an advantage because only a small allocation of original placement costs is left to the period near the end of a property's life. The method also generates more internal funds from depreciation accruals as long as overall gross plant continues to grow. Furthermore, the method gives some recognition to the popular value concept of placing a premium on new models or early changes in the art or technology with attendant high early depreciation.

In an effort to portray higher consumption in early life, the declining balance method produces an inexact allocation of full cost and may produce unwanted fluctuations in annual accrual with group properties. The principal application today is for tax purposes where faster write-off is obtained while preserving flexibility because of the tax provision permitting an easy shift back to straight-line at any plant age.

Sum-of-the-Years-Digits Method

Like the declining balance method, this method results in charging greater depreciation in the early years of service life and gradually reducing the expense with advancing years of plant age. It overcomes one objection to the declining balance method by exactly recovering service value by the end of a property's life.

With this method, the successive years of service life are numbered in reverse order and the depreciation rate to be applied in a particular year is a fraction. The numerator is the number assigned to that year and the denominator is the sum of all the digits by which the years are respectively numbered. The basic formula for the depreciation rate in any year of age n is:

$$d_n = \frac{L - n + 1}{\sum_1^L x} (100 - c) \tag{5}$$

where X is each whole number from 1 to service life L
where c is percent net salvage

For example, with a 10-year service life, the sum is 1+2+3+4+5+6+7+8+9+10=55; and the first year's rate assuming zero salvage, is:

$$d_1 = \frac{10 - 1 + 1}{55} = 18.18\% \tag{6}$$

Similarly the last year's rate is:

$$d_{10} = \frac{10 - 10 + 1}{55} = 1.82\% \tag{7}$$

Whereas the declining balance method yields accruals on a single unit or group of plant which decrease each year along a logarithmic curve, the sum-of-the-years digits accruals decrease by a fixed amount each year along a straight line having a negative slope. Both methods assume higher consumption of plant in early life and leave less to be recovered in later life.

The sum-of-the-years-digits method has found favor where "liberalized depreciation" is claimed for tax purposes. This is because it yields slightly higher results in the early years than the double declining balance method. Few have argued that it represents a true consumption of plant. Moreover, its use for book purposes among utilities is rare.

Sinking Fund Method

The sinking fund method, which takes into account computed interest on the reserve, was one of the early methods to be applied as a full depreciation accounting plan. If the interest rate used is the same as the rate of return, the method produces the same total charge for depreciation and return each year or accounting period. Advocates of the sinking fund method most often justify its use for this reason.

The depreciation rate in the sinking fund method is that annuity rate which, when applied annually over the service life and coupled with interest credits to the reserve at the selected interest rate, will allocate the full cost of plant. The depreciation accrual in any one year is the annuity plus interest on the beginning-of-year reserve. The basic formula for the annuity rate is:

$$d_i = (1 - c)\left[\frac{i}{(1 + i)^L - 1}\right] \tag{8}$$

where c is net salvage
where i is net interest rate
where L is service life

and the annual accrual $= d_iB + iU$ (9)

where B is plant balance
where U is beginning-of-year reserve

Generally, the annuity rate can be determined from tables using the selected values of i and L. If only compound interest tables are available, the alternate expression permits computation of the rate after obtaining a value for $(1+i)^L$, which is the amount by which 1 will increase in L years at interest rate i compounded annually. In group accounting, a value of L slightly shorter than the group average service life is used to compensate for interest not accrued on early retirements.

The above rate formula may be used with a remaining life plan by substituting "E" for "L." This yields a rate which, if applied to the book cost of plant, gives the current year remaining life accrual. The remaining life annuity portion of the total accrual is then derived by subtracting interest on the book reserve. Alternatively, the remaining life annuity rate may be determined directly from the following formula:

$$d_i = (1 - c)\left[\frac{i}{(1 + i)^E - 1}\right] - iu \tag{10}$$

where u is the book reserve ratio
where E is the remaining life

In utility rate making, the sinking fund (compound interest) method can be applied with either a depreciated or undepreciated rate base. The depreciation expense used with the depreciated rate base is the total accrual of the annuity plus interest. This is sometimes termed the modified sinking fund method. The depreciation expense to be used with the undepreciated rate base is the annuity only. The two results will give the same total cost of service if the interest rate and the rate of return are the same. If an interest rate less than the rate of return is used, only the modified sinking fund method avoids an overallowance for return.

Equalizing return and depreciation under the sinking fund method ignores the many other utility costs which are seldom equal from year to year. Compared to the straight-line method, the sinking fund method produces lower early accruals and higher accruals in the later years. This difference increases with an increase in interest rate. Conversely, sinking fund advocates say that the straight-line method is a sinking fund solution with an interest rate of zero. The heavy accruals due to greater interest toward the end of a property's life can produce wide differences between the accumulated accruals and the cost being recovered if retirements occur only a year or two from the estimated time. In other words, the sinking fund method requires closer accuracy in service life and net salvage estimates.

The sinking fund and related interest methods were widely adopted at the time retirement and replacement accounting were being discontinued. At that time, they caused substantial increases in depreciation expenses for many companies. The sinking fund method is rarely used today due to the advance of tax depreciation, first on a straight-line basis and now with more "liberalized" methods; problems of annuity mathematics; and difficulties of proper accruals near the end of a property's life.

Summary

The straight-line method is almost universally used in the utility rate making process. The particular procedure used will vary depending upon the regulatory jurisdiction involved.

The accelerated methods identified above are not generally used for regulatory purposes. The Internal Revenue Service has permitted their use, and modifications of them, in computing tax depreciation, along with other specialized depreciation procedures for taxes. Interest methods, such as the sinking fund method, are no longer in general use.

Category Grouping Procedures

The group plan of depreciation accounting is particularly adaptable to utility property but raises many questions concerning the makeup of the group or category selected for analysis. Rather than one single group containing all utility plant, each group should contain homogeneous units of plant that are generally alike in character, used in the same manner throughout the plant, and operated under the same general conditions. However, even within the framework of this definition, it must be realized that there will be differences in the lives of the individual units.

Consider the case of poles. Some poles will be retired because of storms or other casualties, some because of public convenience or decay, some because of the substitution of underground for aerial facilities, and many more for a combination of the several causes of retirement. There will be a wide dispersion of retirements by age. What then is the proper grouping for a study of poles? Should it be all of the poles owned by the company analyzed en masse? This has not always proven satisfactory because there was a time when it was evident that the life characteristics of untreated poles differed materially from those of treated poles. Accordingly, during the time when untreated poles were substantial in number, it was appropriate to study poles in two separate categories: untreated and treated.

Regardless of which depreciation method is used, several alternatives are available for grouping individual plant units within a depreciation category. The most commonly used grouping procedures are as follows:

1. The Single Unit. Under this procedure each unit of property is depreciated separately. Because the procedure requires separate record-keeping for each unit, it is not practical for most types of property. Thus, it is not widely used by utilities.

2. The Broad Group. Under this procedure all units of plant within a particular depreciation category, usually a plant account or subaccount, are considered to be one group. The Broad Group is widely used and produces reasonably stable depreciation rates from year to year because of its averaging effects. It is a procedure that requires at least accounting records of annual additions and balances. Retirements by vintage are desirable.

3. The Vintage Group. Under this procedure each vintage or placement year within the depreciation category is considered to be a separate group. This combines, into one group, all of the poles placed in a single calendar year, or vintage. Even within each vintage group there will be dispersions of retirements by age, due to the many causes of retirements mentioned above. This requires that each vintage group be analyzed separately to determine its average life; all vintages are composited to produce the average service life for the plant class. Then the depreciation rate may be based on this estimated average service life of the units making up the group.

4. The Equal Life Group (ELG). Under this procedure the plant units are grouped according to their service lives, with the units from each vintage expected to experience the same service life being included in the same life group. This procedure permits accruing the full cost of the shorter-lived units to the depreciation reserve while they are in service. Thus the longer-lived units bear only their own costs. This is accomplished by dividing each vintage group (plant placed in a single year) into smaller groups, each of which is limited to units that are expected to have the same life. This distribution is based on life tables developed from the recorded experience, with respect to the mortality of utility plant. While it is not possible to identify the individual units of plant that will have a given life, it is possible to estimate statistically the number of units or dollars of plant in each equal life group, provided

> mortality data were accumulated. The prediction of future retirement patterns is also necessary in application of the vintage group procedure. However, ELG is much more sensitive to these predictions. ELG may be expected to produce greater fluctuations in depreciation expense from year to year than the broad group procedure.

The Broad Group procedure does not require that an assumption be made concerning the shape of the appropriate survivor curve (see Chapter VI) in the grouping process. However, Vintage Group, as generally applied, and ELG require such a determination. ELG depends upon the survivor curve forecast to determine the subgroups. With the FCC's agreement, the ELG procedure has been widely adopted by telephone companies subject to FCC jurisdiction. Some of the state commissions, however, have disallowed its use for intrastate rate making on both practical and technical grounds. The Vintage Group and Equal Life Group procedures are discussed in more detail in Chapter XII.

Application Techniques

There are two techniques commonly used to determine the depreciation rate to be applied to a utility's plant depreciation categories: Whole Life and Remaining Life.

Whole Life

The Whole Life technique bases the depreciation rate on the estimated average service life of the plant category. Whole life depreciation results in the allocation of a gross plant base over the total life of the investment. However, to the extent that the estimated average service life assigned turns out to be incorrect, (and precision in these estimates cannot reasonably be expected), the Whole Life technique will result in a depreciation reserve imbalance. For example, such over-accrual or under-accrual may remain in the reserve indefinitely unless offset by later overages or underages in the opposite direction. However, when a depreciation reserve excess or deficiency is reasonably certain, the Whole Life technique may be modified to include an adjustment to the accrual rate designed to eliminate the reserve imbalance in the future. For example, a special amortization of the difference may be allowed.

Remaining Life

The Remaining Life technique seeks to recover the undepreciated original cost less future net salvage over its remaining life. With this technique, the gross plant less book depreciation reserve is used as the depreciable cost and the remaining life or future life expectancy is used in the denominator. The formula is:

$$D = \frac{B - U - C'}{E} \qquad (11)$$

where D is the depreciation expense or annual accrual
where B is the book cost of the Gross Plant
where U is the book depreciation reserve at start of the year
where C'is the Estimated Future Net Salvage in dollars
where E is the Estimated Average Remaining Life

The following formula is used to arrive at the depreciation rate in percent:

$$\text{depreciation rate } d = \frac{D}{B} \times 100 \qquad (12)$$

This rate may also be derived by dealing entirely in percentages as follows:

$$\text{depreciation rate } d = \frac{100 - u - c'}{E} \qquad (13)$$

$$\text{where, in percent reserve, } u = \frac{U}{B} \times 100 \qquad (14)$$

$$\text{where, in percent future net salvage, } c' = \frac{C'}{B} \qquad (15)$$

A review of the depreciation reserve is appropriate at the commencement of use of the remaining life technique to ensure consistency with prior accounting and regulatory policies. The desirability of using the remaining life technique is that any necessary adjustments of depreciation reserves, because of changes to the estimates of life on net salvage, are accrued automatically over the remaining life of the property. Once commenced, adjustments to the depreciation reserve, outside of those inherent in the remaining life rate would require regulatory approval.

The Depreciation Model

The foregoing sections of this chapter discussed several depreciation Methods (e.g., Unit of Production, Straight-Line, Declining Balance), Procedures (e.g., Broad Group, Vintage Group, Equal Life Group) and Techniques (Whole Life and Remaining Life). A complete "depreciation model" is composed of a Method, a Procedure and a Technique, e.g., Straight-Line, Vintage Group, and the Remaining Life techniques. Subsequent chapters will also utilize this terminology.

CHAPTER VI

MORTALITY CONCEPTS

Introduction

From the previous discussions of depreciation, it is evident that an estimate of the life of property is essential to most of the common methods of computing depreciation accruals. Estimates may range from somewhat arbitrary assumptions of average life by management to informed judgment based upon highly technical mathematical models derived from actuarial science.

Through observation and classification of peoples' ages at death, actuaries have developed mortality tables. These tables reveal the death rate and life expectancy for people at different ages as a basis for determining life insurance premiums and reserves.

Mortality tables reflect the various risks affecting groups of people. While many people die purely from chance, the great majority of deaths are related to age. This age relationship is shown by the increasing death rate as age increases. Although the life of an individual cannot be predicted with surety, the number of people of a given age who will die in any year can be predicted fairly accurately.

Analogously, physical property is subject to forces of retirement. These forces include those related to the property's physical condition (e.g., wear and tear, accident), functional obsolescence or inadequacy, or termination of the need or enterprise. Industrial counterparts to insurance actuaries assemble and classify the ages at retirement of different types of industrial property in order to study the property's life characteristics.

For life analysis purposes, the ages at retirement are usually expressed in the form of retirement or survivor curves. The graph of the number of retirements at each age is termed the *retirement frequency curve*. The sum of the points on the retirement frequency curve from a specified age to maximum life represents the survivors from the original placements at the specified age. The graph of these survivors at each age is known as the *survivor curve*.

If a group is fully retired, the survivor curve will extend to the maximum life; if the group is not fully retired, the survivor curve is incomplete and is termed a stub survivor curve. Typically, a generalized survivor curve is used. Here, the survivors are expressed as percentages of the total number of units or dollars installed and the points on the curve are referred to as percents surviving.

The survivor curve may be used to obtain an indication of the average of the lives of all the units, or dollars, in the group, i.e., the *average life* of the property. The average life is found by dividing the area under the survivor curve from age zero to maximum life by 100%.

Since the survivor curve must reach maximum life in order for the average life calculation to be made, a stub survivor curve may be extended to maximum life using curve fitting techniques (see Chapter VIII). The vintage average lives may be composited to generate an average life for a group of vintages (e.g., an account) (see Chapter IX).

In lieu of extending the survivor curve, the area under the future portion of the curve, termed the *unrealized life*, may be estimated directly and added to the area under the stub curve, referred to as the *realized life*. The future area may be estimated by multiplying the percent surviving at any age by the vintage's forecasted average remaining life. As explained herein, unrealized life is not synonymous with remaining life nor is realized life synonymous with age.

Average remaining life represents the future years of service expected for the surviving property. The average remaining life for a vintage of any age is found by dividing the area under the estimated future portion of the survivor curve by the percent surviving at that age. Vintage average remaining lives may be composited to generate a remaining life for a group of vintages (e.g., an account).

The *probable life* of a vintage at a given age is the total years of service expected from the survivors. It is found by summing the vintage's age and remaining life.

Ratios may be calculated from the property records to describe the life characteristics of property. A *retirement ratio* for an age interval is the ratio of retirements during the interval to the property exposed to retirement at the beginning of the interval.

Retirement ratios calculated from the property records may be used to develop the observed life table, as discussed in Chapter VIII. In lieu of calculating the observed life table directly from the retirement ratios, *survival ratios* calculated from the retirement ratios may be used to calculate the percents surviving. A survival ratio is the complement of a retirement ratio.

Physical property retirements generally follow definable patterns that can be standardized. The *Iowa curves* are standard curves that were empirically developed to describe the life characteristics of most industrial and utility property. They are used throughout the utility industry, as well as in other applications[1] where life characteristics are sought. Their use in extending stub survivor curves and forecasting life characteristics is discussed in Chapter VIII.

The curves were placed into *L, R,* or *S* families depending upon whether the highest point (mode) of the retirement frequency curve was *left* of, *right* of, or *symmetrical* to the curve's average life. The curves in each family were then ordered according to the magnitude of the mode from low (e.g., *L0*) to high (e.g., *L5*).

The Iowa curve set was expanded to 31 curve types. This was accomplished by combining the original curves to form *half* curves (e.g., *S0.5*) and adding the *O* curves, so-called because their mode is at the origin. For any one of the 31 curve types, curves with different average lives may be generated by varying the area under curves of a given type. The development and validation of the curves are discussed in Appendix A, part 3.

Standard curves other than the Iowa curves may be used to describe history and predict the future. One such set of curves is the *New York h curves*. These curves are not empirical but were developed by truncating the normal frequency curve. The *h* curves are used by the New York Department of Public Service and most New York utilities, as well as some other utilities and several consultants. The development and application of the *h* curves are discussed further in Appendix A, part 5.

Another mortality formula, the Gompertz-Makeham formula, was not developed from empirical testing of industrial property but was formulated to describe human mortality. The

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[1] An example is their use to describe the life of bank accounts.

development of the formula and its application to utility data are discussed in Appendix A, parts 1 and 2.

Retirement and Survivor Curves

Fundamental to the appropriate use of the survivor curve methodology is an understanding of the development and underlying properties of survivor curves and other curves associated with them. The retirement frequency and survivor curves are defined and developed in this section.

Retirement Frequency Curve

For a group of property, retirements do not typically occur at a single age but are distributed from age zero to the group's maximum age (i.e., maximum life). The graph of the number of retirements at each age is termed the retirement frequency curve.

The age at which the greatest number of retirements occurs is termed the modal age, and the associated point on the retirement frequency curve is referred to as the mode of the curve. Generally, the modal age is positioned near the average of all the retirement ages (i.e., average life) (see Figure 6-1).

A retirement frequency curve may be expressed in units or dollars. Alternatively, the curve may be generalized by expressing the retirements at each age as percentages of the total number of units or dollars (see Figure 6-1). The area under such a generalized curve from age zero to maximum life is 100%. The ages may also be generalized by expressing them as percentages of average life (see Iowa curve discussion in Appendix A, part 3).

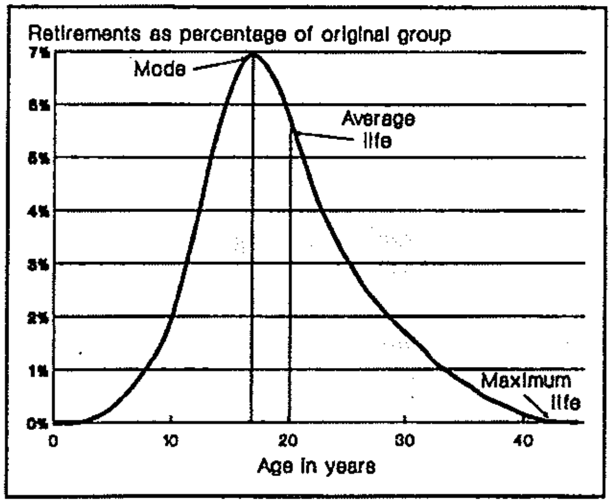

Figure 6-1. Retirement Frequency Curve.

Survivor Curve

The sum of the points on the retirement frequency curve from a specified age to maximum life represents the plant remaining in service (i.e., the survivors from the original placements) at the specified age. The graph of the survivors at each age beginning with age zero is known as the survivor curve. If a group is fully retired, the survivor curve will extend to maximum life; otherwise, it is referred to as a *stub* survivor curve.

The survivors may be expressed in units or dollars. Typically, a generalized survivor curve is used; here the survivors are expressed as percentages of the total number of units or dollars installed and the points on the curve are referred to as percents surviving (see Figure 6-2). The ages may also be generalized by expressing them as percentages of average life (see Iowa curve discussion in Appendix A, part 3).

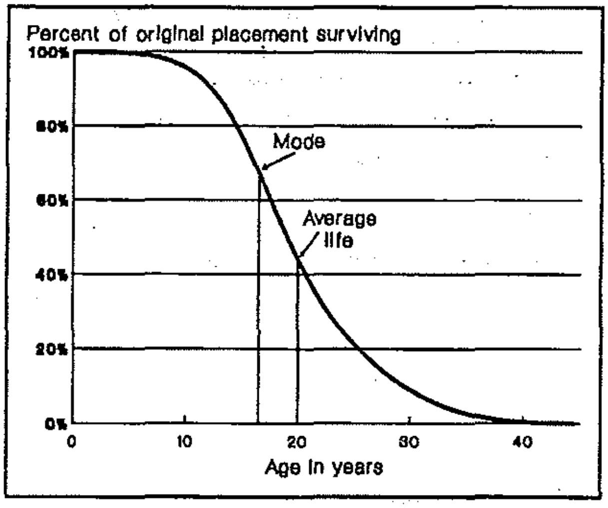

Figure 6-2. Survivor Curve.

The greatest decrease in percent surviving (i.e., the steepest slope of the curve) occurs at the age that is the modal age of the retirement frequency curve. Generally, this point of inflection of the survivor curve is positioned near the group's average life.

If the survivor curve is known, the retirement frequency curve may then be calculated. The number retired (or percent retired) during an age interval (e.g., 2.5 years to 3.5 years) is the difference between the number surviving (or percent surviving) at the beginning and the end of the age interval.

Types of Lives

Various types of average lives may be calculated to describe the life characteristics of property. The following terms are used to refer to the types of lives discussed in this section: *average, realized, unrealized, remaining, probable.*

Average Life

A commonly used statistic in life analysis and life estimation is the average life[2] of the property. This is the average of the lives of all the units, or dollars, in the group from age zero to maximum life. The average life (AL) is calculated by weighting each age (i) at which property was retired by the number retired (R) at that age and dividing the sum of these products by the total installed, as shown below:

$$AL = \frac{\sum_{i=0}^{\text{max life}} (i*R_i)}{\text{total installed}} \qquad (1)$$

Where sufficient mortality data are available, an indication of average life may be determined from a survivor curve constructed for the property group. To calculate average life, the area under a survivor curve (SC) from age zero to maximum life is divided by the total installed (or 100% for a generalized curve):

$$AL = \frac{\text{area under SC from age 0 to max life}}{100\%} \qquad (2)$$

The average life calculated above is a direct weighted average. To illustrate this averaging, consider a set of horizontal trapezoids constructed so as to cover the area under the survivor curve from age zero to maximum life. The trapezoids are formed by breaking the y

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[2] When an account is considered as a single group, the terms average life and average service life are interchangeable.

axis into segments; each segment represents the height of a trapezoid. Horizontal lines drawn from the y axis to the survivor curve form the bases of the trapezoids, as shown in Figure 6-3.

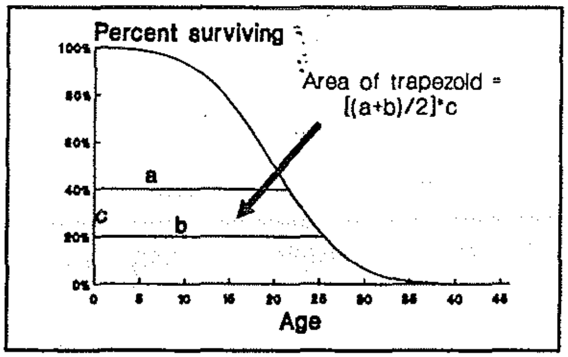

Figure 6-3. Calculation of Average Life from Survivor Curve.

Since the trapezoids cover the area under the curve, summing the areas of the trapezoids provides the total area under the survivor curve. The area of a trapezoid is found by multiplying the average of its bases, (a+b)/2, by its height (c) as shown in Figure 6-3. Since in survivor curve terminology, (a+b)/2 represents the age at retirement for the proportion of property identified by c, the area formula may be interpreted as the weighting of a retirement age by the amount of property retiring at that age. The total area under the survivor curve, then, is the direct weighted average of the various ages at retirement.

For a group not fully retired, the average age of the retirements to date is a lower bound to the average life in that it does not consider property not yet retired. Because the survivor curve must reach maximum life in order for the average life calculation to be made, a stub survivor curve may be extended to maximum life using curve fitting techniques (see Chapter VIII).

The vintage average lives may be composited to generate an average service life for the account. The composite life will vary depending upon the type of averaging (e.g., direct, reciprocal) and the weighting (e.g., net plant) (see Chapter IX).

If the area under a vintage's survivor curve (SC) is divided into areas to the left and right of the current age x, then the average life calculation may be restated as follows:

$$\text{average life} = \frac{\begin{array}{c}\text{area under SC}\\ \text{to left of x}\end{array}}{100\%} + \frac{\begin{array}{c}\text{area under SC}\\ \text{to right of x}\end{array}}{100\%} \qquad (3)$$

Substituting terms used in the survivor curve methodology for the areas above gives the following equation:

$$\text{average life} = \text{realized life} + \text{unrealized life} \tag{4}$$

In practice, a vintage's unrealized life is estimated and added to the property's calculated realized life (see Chapter IX). Both realized and unrealized life are discussed below.

Realized Life

A vintage's realized life is the average years of service experienced to date from the vintage's original installations. In other words, it is the average of the vintage's age and the lives of the vintage's retirements to date. This direct weighted average is determined by dividing 100% into the area under the vintage's survivor curve (SC) from age zero to age x:

$$\text{realized life at age } x = \frac{\text{area } \textit{under} \text{ SC from age 0 to } x}{100\%} \tag{5}$$

If all of a vintage's original installations are surviving, then the vintage's realized life is equal to its age. *If there have been retirements, realized life will be LESS than the vintage's age.*

Unrealized Life

A vintage's unrealized life (sometimes referred to as future life) is the future unit-years (or dollar-years) of service expected from the current survivors divided by the original installations. This direct weighted average is estimated by dividing 100% into the area under the estimated future portion of the survivor curve (SC) from age x to maximum life:

$$\text{unrealized life at age x} = \frac{\text{area under SC from age x to max life}}{100\%} \tag{6}$$

If all of a vintage's original installations are surviving, then unrealized life is equal to average remaining life. *If there have been retirements, unrealized life will be LESS than the property's average remaining life* (see Equation 9).

The significance of the unrealized life lies in its use in estimating the average life of a vintage (Equation 4). For this use, unrealized life for a vintage of age x is commonly estimated by multiplying the proportion surviving at age x, $\mathbf{S_x}$, by the vintage's remaining life forecasted at age x, $\mathbf{RL_x}$:

$$\text{unrealized life at age } x = S_x * RL_x \tag{7}$$

Average Remaining Life

Average remaining life (i.e., life expectancy) represents the future years of service expected from the surviving property. The average remaining life for a vintage is the average of the remaining lives expected for all the surviving units, or dollars, in the group.

The average remaining life at age x, $\mathbf{RL_x}$, is calculated by weighting each expected remaining life (j) by the survivors expected to have that remaining life (S_j) and dividing the sum of these products by the total survivors, as shown below:

$$RL = \frac{\sum_{j=x}^{\text{max life}} (j * S_j)}{\text{total survivors}} \tag{8}$$

When sufficient mortality data are available, an indication of remaining life may be determined from a survivor curve constructed for the property group. To calculate the average remaining life at age x, the area under the estimated future portion of the survivor curve (SC) is divided by the percent surviving at age x, $\mathbf{S_x}$:

$$RL_x = \frac{\text{area under SC from age x to max life}}{S_x} \tag{9}$$

The remaining life calculated above is a direct weighted average. To illustrate this averaging, consider a set of horizontal trapezoids constructed to cover the area under the survivor curve from age x to maximum life. The trapezoids are formed by breaking the height of the survivor curve at age x into segments; each segment represents the height of a trapezoid.

Horizontal lines drawn from a vertical line at age x to intersect the survivor curve form the bases of the trapezoids (see Figure 6-4).

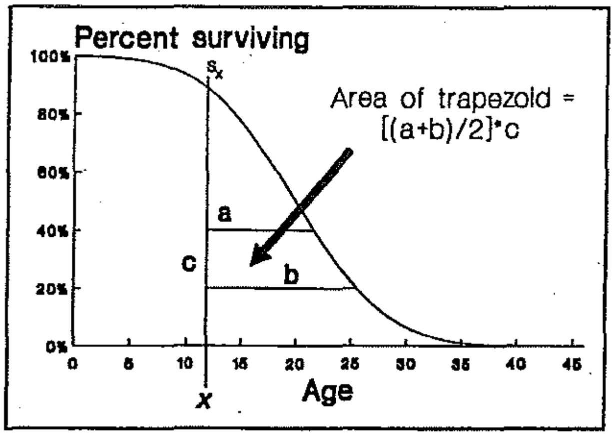

Figure 6-4. Calculation of Average Remaining Life.

Because the trapezoids cover the area under the survivor curve to the right of age **x**, summing the areas of the trapezoids gives this future area. Since **(a+b)/2** represents the remaining life for a proportion of survivors (**c**), the area formula defined in Figure 6-4 may be interpreted as weighting a remaining life by the proportion of survivors expected to have that remaining life. Dividing the sum of these areas by the percent surviving at age **x**, **S_x**, is analogous to dividing the direct weighted remaining lives by the sum of the weights since the trapezoid heights sum to S_x.

The vintage average remaining lives may be composited to generate an average remaining life for a group of vintages (e.g., an account). The result will vary depending upon the type of averaging (e.g., direct, reciprocal) and the weighting (e.g., net book weighting) (see Chapter IX).

Probable Life

The probable life of a vintage at a given age is the total years of service expected from the survivors from age zero to their forecasted retirement. It is calculated by summing the vintage's age and its average remaining life:

$$\text{probable life} = \text{age} + \text{average remaining life} \qquad (10)$$

A probable life curve is shown in Figure 6-5 along with its associated survivor curve.

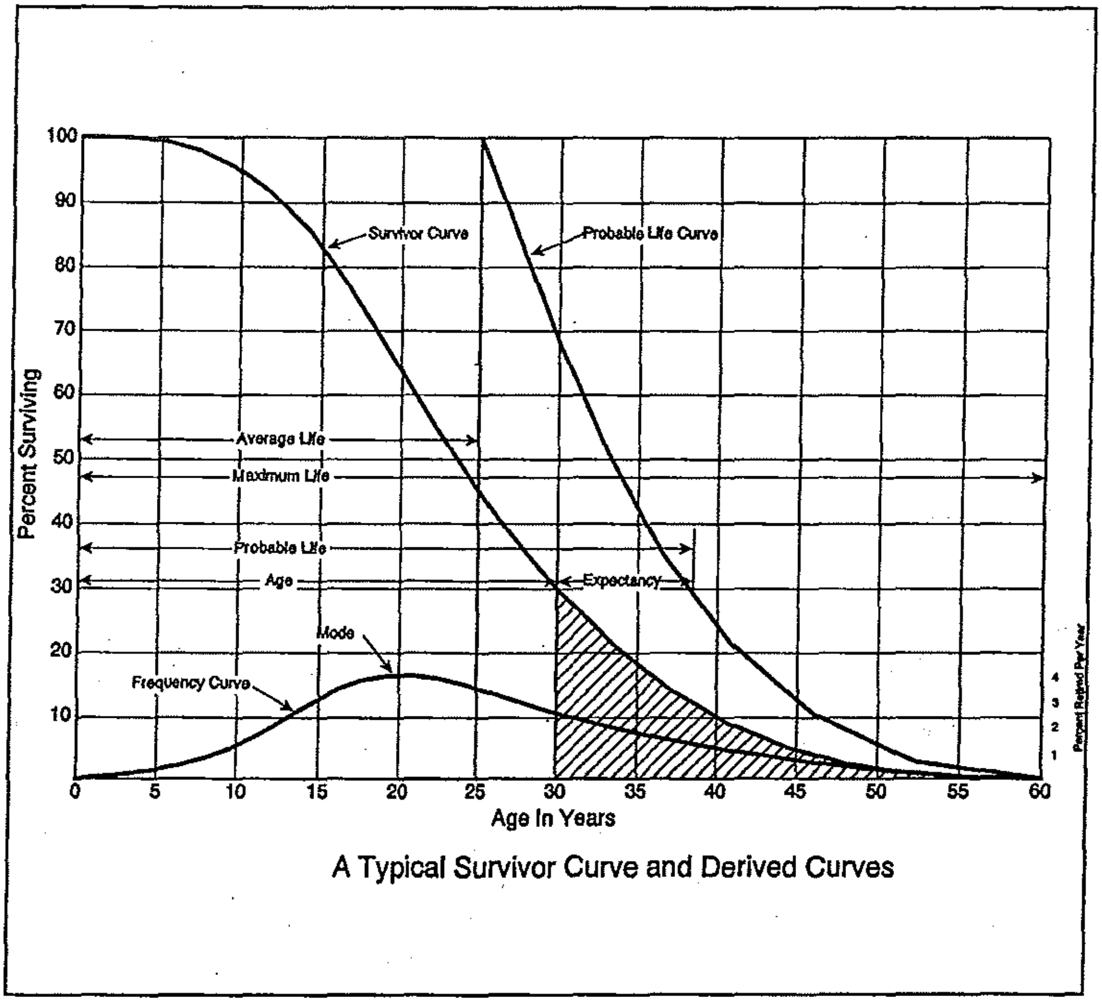

Figure 6-5. Probable Life Curve.[3]

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[3] Plotted by Gannett Fleming Valuation and Rate Consultants, Inc.

The probable life for property of a specified age x may be determined using the survivor curve and the probable life curve. First, the percent surviving at age x, S_x, is determined from the survivor curve. Next, the point on the probable life curve which is on a horizontal line with S_x is located. The number of years on the age axis associated with the point located on the probable life curve is the probable life of the survivors of age x.

The above rule for determining probable life is based upon Equation (10) and the fact that the probable life curve is constructed such that for any age, the horizontal distance between the survivor curve and the probable life curve represents the average remaining life for property of the specified age.

From the probable life curve, it can be seen that probable life and average life coincide at age zero. The probable life for any age greater than zero is greater than average life because the shorter lived units have been removed from the average.

Retirement and Survival Ratios

Ratios may be calculated from the property records to describe the life characteristics of property. Retirement and survival ratios are discussed in this section.

Retirement Ratio

The retirement ratio for age interval x, rr_x, represents the retirements during the interval as a proportion of the property exposed to retirement at the beginning of the interval. The retirement ratio is calculated by dividing the retirements during the interval by the exposures at the beginning of the interval:

$$rr_x = \frac{\text{retirements during age interval x}}{\text{exposures at beg. of age interval x}} \qquad (11)$$

Retirement ratios calculated from the property records may be used to develop the percent surviving for each age interval of the survivor curve. The curve begins with 100% surviving at age zero. For each age interval, the percent surviving at the end of the interval S_{x+1} is calculated from the percent surviving at the beginning of the interval, S_x, using the retirement ratio calculated for the age interval, rr_x:

$$S_{x+1} = S_x - (rr_x * S_x) \qquad (12)$$

The retirement ratio is a conditional statistic. Interpreted in terms of probabilities, it represents the probability that the property surviving at the beginning of an age interval will be retired during the interval.

By contrast, a point on the retirement frequency curve is not a conditional statistic. It represents the probability that the original installations (not just the survivors) will be retired during an age interval. These probabilities generally increase from age zero to the modal age and then decrease with age to reflect the probability that some of the original installations will be retired prior to reaching the later age intervals.

Under the assumption that the forces of mortality increase with age, retirement ratios for a property group will generally, although not strictly, increase with age. The ratios range from zero to one. A retirement ratio of zero causes the survivor curve to be temporarily horizontal. A retirement ratio of one results when all of the survivors are retired during the age interval, which occurs at the group's maximum life.

If the survivor curve is given, retirement ratios may be calculated. The difference between the percents surviving at the beginning and the end of an age interval is divided by the percent surviving at the beginning of the interval. This provides the retirement ratio for the interval:

$$rr_x = \frac{S_x - S_{x+1}}{S_x} \qquad (13)$$

Survival Ratio

In lieu of calculating the observed life table directly from the retirement ratios, survival ratios may be calculated from the retirement ratios and used to calculate the percents surviving. A survival ratio is the complement of a retirement ratio:

$$\text{survival ratio} = 1 - \text{retirement ratio} \qquad (14)$$

To calculate the survivor curve, the survival ratio for an age interval x, sr_x, is multiplied by the percent surviving at the beginning of the interval, S_x, to calculate the percent surviving at the end of the interval S_{x+1}:

$$S_{x+1} = S_x * sr_x \qquad (15)$$

Analogous to the retirement ratio, the survival ratio is a conditional statistic. It represents the probability that the property surviving at the beginning of an age interval will survive to the next age interval.

The ratios range from one to zero. A survival ratio of one results when none of the survivors is retired during the age interval, which causes the survivor curve to be horizontal temporarily. A survival ratio of zero results when all of the survivors are retired during the age interval, which occurs at the group's maximum life.

If the survivor curve is given, survival ratios may be calculated. The percent surviving at the end of age interval x, S_{x+1}, is divided by the percent surviving at the beginning of the age interval, S_x, to give the survival ratio for the age interval:

$$sr_x = \frac{S_{x+1}}{S_x} \tag{16}$$

CHAPTER VII

TURNOVER AND SIMULATION ANALYSES

Introduction

As discussed in the previous chapter, actuarial methods are used to analyze retirements that took place at various ages in relationship to the property exposed to the risk of retirement. "Turnover" methods may be used to study retirements in relation to plant balances irrespective of the age of the property retired. Although actuarial methods yield more reliable results, they require considerably more detailed data. Turnover methods are used when actuarial (i.e., aged) data are lacking or when a more elaborate study is not economical or not possible.

Turnover methods provide an indication of the average life of the property. The methods assume the account balance is growing uniformly and the dispersion of retirements is the same for each vintage. A more reliable estimate may be made if the property has experienced at least one life cycle (roughly twice its average life) since, under the constancy assumptions above, the property will have reached stability.

The *Turnover-Period* method is based, as its name indicates, on the turnover period, which is the time required to exhaust a balance through successive annual retirements. The period is converted into an estimate of average life using the property's calculated account growth rate and estimated dispersion.

The *Half-Cycle* method was developed to overcome the Turnover-Period method's requirement that data be available for a period approximating average life. This method requires data for only half of the average life and is more responsive to trends. As with the full Turnover-Period method, adjustment factors based on the account growth rate and retirement dispersion are used to convert a preliminary calculation to a life indication. The Half-Cycle method may be used simultaneously with the Turnover-Period method to provide an indication of the retirement dispersion.

The *Asymptotic* method and its simplified form, the *Geometric Mean* method, are based on ratios of annual additions and retirements. The latter method more readily indicates trends but is also prone to producing results with considerable variability.

The simplicity of the turnover methods and ease with which they may be applied explain their popularity. Their use is restricted by the assumptions of uniformity and their failure to provide an indication of retirement dispersion. These problems led to their replacement by the *Simulated Plant Record (SPR)* model.

The selection of retirement dispersion (e.g., Iowa curve) by the SPR model is based upon the closeness of the match between actual annual amounts and those that have been simulated. In the "Balances" method, annual balances are compared. In the "Cumulative Retirements" and "Period Retirements" methods, retirements are compared.

The closeness of the match between balances is measured by the Conformance Index (CI) or its reciprocal, the Index of Variation (IV). The maturity of the account is measured by the Retirement Experience Index (REI).

In lieu of analyzing unaged data, aged data may be simulated and then analyzed using actuarial methods. The *Statistical Aging (STAGE)* and *Computed Mortality (CM)* models are used to simulate aged data.

In this chapter, the turnover and simulation models are explained. Included is a discussion of the models' application and limitations.

Turnover Methods

Overview

The turnover methods are based upon the general theory that the time it takes the plant to "turn over" (i.e., the time it takes the retirements to exhaust a previous plant balance) is a measure of its service life. These methods are useful in cases where the past retirements cannot be aged.

A drawback to some of the methods is their requirement of a comparatively long record of annual balances, additions, and retirements. In addition, a somewhat arbitrary life adjustment must be made if the property has experienced growth or dispersion in retirements.

The methods produce an indication of average life but not a retirement dispersion pattern. An indication of dispersion may sometimes be developed through simultaneous application of the Turnover-Period and Half-Cycle methods.

Four turnover methods are discussed below, followed by a discussion of their limitations.

Turnover-Period Method

The Turnover-Period method may be used to calculate a turnover period, which is then adjusted to provide an indication of average life. The adjustment takes into consideration two parameters: account growth rate, which must be uniform; and type of retirement dispersion, which must be the same for each vintage. The method does not produce an indication of retirement dispersion.

The turnover period calculations require a history of annual amounts (balances, retirements, and/or additions) for a period of years approximating average life or more. A more reliable estimate may be made if the property has experienced at least one life cycle (roughly twice average life). This is because the turnover period will have stabilized assuming constant growth and a fixed dispersion pattern.

As mentioned above, a turnover period is the number of years for a plant balance to be exhausted by successive annual retirements. Therefore, the calculation may be made by subtracting successive annual retirements from a given plant balance until the balance is reduced to zero. Equivalent calculation options are listed below:

1. Accumulate annual retirements backward from any given date until their sum equals the balance in the account at the date at which summing *ceases*. The turnover period is the number of years in the summation.

2. Accumulate gross additions backward from any given date until their sum equals the balance in the account at the date at which summing *began*. The turnover period is the number of years in the summation.

3. Plot the cumulative retirements and the cumulative gross additions by year from the beginning of the account. The turnover period, at a specified time, is the horizontal distance between the curves, measured backward from the retirement curve at the specified time.[1]

The turnover period in Table 7-1 was calculated using options 1 and 2. Option 3 could not be calculated since data from the beginning of the account were not available. Using option 1, retirements were accumulated backward from the end of 1995 until the sum equaled or exceeded the plant balance. In this case, the sum ($155,468) lies between the end-of-year balances for 1985 and 1986; interpolation indicates a turnover period of 9.7 years. Using option 2, the additions are accumulated backward from the end of 1995. A portion of the 1986 additions must be included in order for the accumulated additions to equal the 1995 account balance ($246,500). Interpolation also indicates a turnover period of 9.7 years.

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[1] American Gas Association, *Methods of Estimating Utility Plant Life*, Edison Electric Institute, Publication No. 51023, 1952, 19.

TABLE 7-1

CALCULATION OF TURNOVER PERIOD

Year	Gross Additions During Year	Retirements During Year	Balance End of Year	Retirements Cumulative from End of 1995	Additions Cumulative from End of 1995
1982			101,900		
1983	17,514	8,914	110,500		
1984	19,792	9,192	121,100		
1985	33,308	9,408	145,000		
1986	36,919	9,669	172,250	155,468	256,968
1987	27,940	10,130	190,060	145,799	220,049
1988	28,416	10,976	207,500	135,669	192,109
1989	24,736	12,226	220,010	124,693	163,693
1990	24,061	13,871	230,200	112,467	138,957
1991	22,580	15,780	237,000	98,596	114,896
1992	22,790	17,840	241,950	82,816	92,316
1993	17,042	19,892	239,100	64,976	69,526
1994	22,864	21,764	240,200	45,084	52,484
1995	29,620	23,320	246,500	23,320	29,620

Turnover Period
9.7 years (option 1)
9.7 years (option 2)

The turnover period equals the average life of the property if the plant balance and retirement dispersion have remained constant during the turnover period and for some time prior. If the plant balance is changing at a uniform rate and the dispersion is constant, life adjustment factors may be used to adjust the turnover period.[2]

The growth ratio is the quotient of the plant balance at the end and beginning of the turnover period. The survivor curve estimate may be made by applying the SPR model, if appropriate, or using the results of actuarial studies of other utilities. Alternatively, the Half-Cycle method may be used in conjunction with the Turnover-Period method to produce a dispersion estimate (as discussed under the Half-Cycle method below).

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[2] EEI, 1952, 20-21 and NARUC Depreciation Subcommittee of the Committee on Engineering Depreciation, and Valuation, *Public Utility Depreciation Practices* (Washington, D. C.: NARUC, 1968), 140-141.

The use of life adjustment factors is illustrated in Table 7-2 using the turnover period estimated in Table 7-1 and adjustment percentages[3] for two different curves—#2 and #3. The calculations indicate an average life of approximately ten years. In actuality, consideration would be given to calculations made over several turnover periods.

TABLE 7-2

USE OF LIFE ADJUSTMENT FACTORS

	Curve #2	Curve #3	Balances
Final Balance -- 1995			$ 246,500 (A)
Initial Balance (Interpolated)			152,725 (B)
Growth Ratio (A) / (B)	1.6	1.6	
Turnover Period (yrs)	9.7	9.7	
Adjustment (%)	4.3	2.4	
Estimated ASL (yrs) 9.7 * (1 + adj %)	10.1	9.9	

The calculation in Table 7-3 reveals that the greater the turnover period, the greater the variation in years in the adjusted average life (AL). Thus, choosing an appropriate dispersion curve is especially critical for accounts with longer lived property.

TABLE 7-3

SENSITIVITY OF LIFE ADJUSTMENT FACTOR TO PROPERTY LIFE

	Turnover Period=10yrs		Turnover Period=20yrs	
	Curve#1	Curve#2	Curve#3	Curve#4
Growth Ratio	4.0	4.0	4.0	4.0
Adjustment (%)	42.0	2.7	42.0	2.7
Estimated AL (yrs)	14.2	10.3	28.0	20.5

From the calculation in Table 7-4 it can be seen that the higher the growth ratio, the greater the variation in adjustment depending upon the dispersion curve that is used. This

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[3] NARUC Depreciation Subcommittee, 1968.

conclusion implies that choosing an appropriate dispersion curve is especially important for accounts with higher growth ratios.

TABLE 7-4

SENSITIVITY OF LIFE ADJUSTMENT FACTOR TO GROWTH RATIO

	Growth Ratio=2		Growth Ratio=4	
	Curve#1	Curve#6	Curve#1	Curve#6
Turnover Period (yrs.)	20.0	20.0	20.0	20.0
Adjustment (%)	15.5	1.4	42.0	2.7
Estimated AL (yrs)	23.1	20.3	28.4	20.5

The Turnover-Period method may also be used to indicate the average age of surviving plant (see Table 7-5). Calculation option 2 described above is used to determine the number of vintages included in the surviving plant. These vintages are aged using the half-year convention and their direct dollar weighted average age is calculated.

TABLE 7-5

CALCULATION OF AVERAGE AGE OF SURVIVING PLANT

Vintage	Gross Adds ($)	Age (Years)	Dollar Years (Gross Adds * Age)
1995	29,620	0.50	14,810
1994	22,864	1.50	34,296
1993	17,042	2.50	42,605
1992	22,790	3.50	79,765
1991	22,580	4.50	101,610
1990	24,061	5.50	132,336
1989	24,736	6.50	160,784
1988	28,416	7.50	213,120
1987	27,940	8.50	237,490
1986	26,451	9.35	247,317
Total	246,500		1,264,132
Calculated Average Age: 1,264,132 / 246,500 = 5.1 yrs.			

In Table 7-5, the age of the 1986 vintage reflects the adjustment for the fractional year (0.7) in the turnover period (9.7). Therefore, the age of the additions is 9 +(0.7/2)=9.35. The calculated average age is adjusted using age adjustment factors which are a function of the retirement dispersion and the growth ratio.

For consistency, the growth ratio and survivor curve used to determine the average life adjustment should be used to determine the age adjustment factor. The use of age adjustment factors is illustrated in Table 7-6 using the average age from Table 7-5 and adjustment factors.[4]

TABLE 7-6

USE OF AGE ADJUSTMENT FACTORS

	Curve #2	Curve #3
Growth Ratio	1.6	1.6
Average Age (yrs)	5.1	5.1
Adjustment (%)	15.5	9.0
Estimated Average Age (yrs) 5.1 * (1 + Adj %)	5.9	5.6

Adjustment factors are intended for cases in which the growth rate is uniform, the retirement dispersion is the same for all vintages, and the account is old enough to have passed through one complete life cycle. When there is marked irregularity of growth or the account is immature (often indicated by high growth ratios), the adjustment factors should be used with caution. However, according to the *1943 NARUC Report*[5], unless one or both of these two conditions is extremely evident in an account, the Turnover-Period method will give results that are usable for most practical purposes.

Further discussion of the Turnover-Period method and its appropriate application may be found in the *1943 NARUC Report*.

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[4] NARUC Committee on Depreciation, *Report of the Committee on Depreciation* (Washington, D. C.: NARUC, 1943), 258.

[5] NARUC Committee on Depreciation, 1943.

Half-Cycle Method

The Half-Cycle method was developed by Paul Jeynes, Public Service Electric and Gas Company, to overcome some of the frailties of the above method. For example, this method requires data for only one-half average life, which is one-half of the period required by the Turnover-Period method. As with the Turnover-Period method, a more reliable estimate may be made if the account has experienced one life cycle (approximately twice average life). Since the method requires less data than the Turnover-Period method, it is more responsive to changes and trends.

As with the Turnover-Period method, a preliminary life estimate is calculated and then adjusted for growth and retirement dispersion. The preliminary life estimate is made using the following trial and error procedure:

1. Calculate a "half cycle" by dividing an arbitrary trial life estimate by two.

2. Divide the retirements in any year into the balance a half-cycle earlier.

3. If the quotient is within one year of the trial life, apply adjustment factors to the average of the quotient and the trial life to develop a life estimate.

   If not,

   Repeat the above steps using as the next trial life the average of the quotient obtained in step 2 and the previous trial life.

The above steps are illustrated in Table 7-7 using the sample data in Table 7-1.

TABLE 7-7

CALCULATION OF LIFE ESTIMATE BY HALF-CYCLE METHOD

1995 Retirements	$ 23,320
Initial Trial Life (yrs)	11.0
Initial Half Cycle (yrs)	5.5
Initial Trial Quotient (yrs)	
(Avg of 1989 and 1990 balances) / 1995 Ret	
= $225,105 / $23,320=	9.7

Since 9.7 is more than one year away from the initial trial life, repeat the above steps using (11.0 + 9.7)/2 = 10.4 as the next trial life. In actuality, consideration would be given to calculations made over several periods.

As in the previous method, the life estimate represents the average life of the property if the growth ratio and retirement dispersion have remained constant. If the account is growing, the life estimate must be adjusted. The mathematics of the model assume that the change is linear, i.e., in equal annual amounts.

As with the Turnover-Period method, the factors used to adjust the preliminary estimate are a function of the growth ratio and the dispersion. The growth ratio is the quotient of the plant balance at the end and beginning of the half-cycle period. The dispersion estimate may be made by applying the SPR model to the data or by using the results of actuarial studies of other utilities' aged data for similar property.

The Half-Cycle method may be used simultaneously with the Turnover-Period method to indicate the retirement dispersion. First, multiple life indications are developed for each method using adjustment factors based on the calculated growth rate and each of the Iowa curves. Then, for each curve type, the lives indicated by the two methods are compared. The dispersion chosen is that for which the difference between average lives indicated by the two methods is minimal. The average of the indicated lives for the chosen curve type is used as the life indication.

Further discussion of the Half-Cycle method may be found in the *1943 NARUC Report*.

Asymptotic Method

The Asymptotic method, developed by Joseph Jeming, proposes that a life estimate may be obtained using the limiting values, or asymptotes, of the additions and retirements ratios.[6] The method assumes that the account has stabilized and that balances are either constant or changing at a constant rate.

The life estimate is the reciprocal of the geometric mean of the limiting values of the additions and retirements ratios, as shown below:

$$\textit{life estimate} = \frac{1}{\sqrt{ar}} \qquad (1)$$

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[6] Jeming, J., "An Asymptotic Method of Determining Annual and Accrued Depreciation," in Scharff, Leerburger, and Jeming *Depreciation of Public Utility Property*, 1940.

where a is the limiting value of the additions ratios
(additions ratio = additions / plant balance)

where r is the limiting value of retirement ratios
(retirement ratio = retirements / plant balance)

If the plant is static (i.e., zero growth), "a" is equal to "r" and the life indication is the reciprocal of either value.

The values for "a" and "r" may be estimated by determining additions and retirements ratios in each year and fitting to each series a curve of the following form:

$$Y = a + bx^{-1} + cx^{-2} + \ldots \tag{2}$$

where Y is the additions (or retirements) ratio
where a is the asymptote
where b, c are constants to be determined from fitting data

Curve fitting and a statistical index to indicate the significance of the result were proposed by Mr. Jeming.[7] Alex Bauhan of Public Service Electric and Gas Co. of New Jersey developed calculation forms which illustrate the proposed procedures.[8]

In order to address the problem of erratic annual ratios, Jeming proposed using cumulative data if the complete history from the beginning of the account is available. This modification is also used when the limiting value of the retirement ratios exceeds that of the additions ratios. An alternative to using cumulative data over the entire history is to accumulate data over short intervals, e.g., at least ten separate intervals of three to five years each.

Geometric Mean Method

The Geometric Mean method was developed by Joseph Jeming as a simplification of the Asymptotic method to be applied when the best fit to the ratios is a straight line. The method assumes that the growth rate and average life have remained fairly constant for at least one life cycle (roughly twice average life). As with the other turnover methods, this method does not produce an indication of dispersion.

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[7] Jeming, 1940.

[8] EEI, 1952.

The life estimate is the reciprocal of the geometric mean of the additions and retirements ratios averaged over a period of years:

$$\text{life estimate} = \frac{1}{\sqrt{ar}} \qquad (3)$$

where a is the average additions ratio
where r is the average retirements ratio

If the plant is static (i.e., zero growth), "a" is equal to "r" and the life indication is the reciprocal of either value.

As with the Asymptotic method, the presence of erratic annual ratios may force the consideration of cumulative data. This modification is also used when "r" > "a".

The calculation of a life estimate by the Geometric Mean method is illustrated below using cumulative data from Table 7-1. The gross additions and retirements accumulated backward from 1995 through 1985 are $290,276 and $164,876, respectively. The sum of plant balances from 1995 through 1985 is $2,369,770. Using these amounts, the additions ratio (a) and retirements ratio (r) may be calculated:

$$a = \frac{290{,}276}{2{,}369{,}770} = 0.1225$$

$$r = \frac{164{,}876}{2{,}369{,}770} = 0.0696$$

Therefore, the life estimate is calculated as follows:

$$\text{life estimate} = \frac{1}{\sqrt{0.1225 \times 0.0696}} = 10.8$$

An alternative to using cumulative data over the entire history is to accumulate data over short intervals, e.g., at least ten separate intervals of three to five years each. If the data are highly irregular, this modification may succeed in indicating trends but not produce a reliable life indication.

Limitations

A major drawback to all of the turnover methods is that they do not provide an indication as to the retirement dispersion pattern. This limitation is most pronounced with the Turnover-Period method, which requires a dispersion estimate if the account balance has been changing. As noted above, some indication as to dispersion may be gained from simultaneous application of the Turnover-Period and Half-Cycle methods.

All the methods assume uniformity for the growth ratio and the dispersion of retirements for each vintage. A more reliable estimate may be made if the property has experienced at least one life cycle (roughly twice average life) since, under the constancy assumptions above, the property will be at stability.

Since utility property typically does not meet the above constancy assumptions, the methods may produce considerable variation in life indications. This is especially true for the Geometric Mean method. Therefore, modifications involving smoothing or the use of cumulative data have been proposed.

A drawback of the above modifications is that they may mask trends. Trends are most readily revealed by the Half-Cycle method and most concealed by the Turnover-Period method.

The use of turnover methods has decreased considerably with the increased experience in applying and interpreting the results of improved life analysis methods. These improved methods used with unaged data are discussed in the following sections.

Simulated Plant Record Method

Overview

The Simulated Plant Record (SPR) method is used by utilities and commissions to indicate generalized survivor curves that best represent the life characteristics of property when the property records do not contain the age of the property upon retirement. The selection of curves is based upon the closeness of the match between actual and simulated annual amounts.

The closeness of the match between annual amounts is measured by the Conformance Index (CI) or its reciprocal, the Index of Variation (IV). These measures are based upon the sum of squared differences between simulated and actual annual amounts. The highest ranked curves are those with the highest CIs (or lowest IVs).

The maturity of the account is measured by the Retirement Experience Index (REI). The higher the REI, the more assurance that a unique retirement pattern was used in the simulation. In 1947, Bauhan proposed a scale to rank the REI and the CI from poor to excellent.

The amounts that are compared may be balances or retirements depending upon which model is used: SPR Balances, SPR Period Retirements, or SPR Cumulative Retirements. The SPR Balances model is discussed in detail below, followed by a brief look at the retirements models. The CI, IV, and REI measures are explained and illustrated.

Development of SPR Method

The development of the SPR method began with the simulations performed by Cyrus Hill and described in *Telephony* in 1922. In his work with telephone data, Hill simulated vintage survivors by multiplying the vintage additions by the percents surviving from a survivor curve. He varied either the curve shape or average life in order to calculate survivors that summed to within 1% of the book balance. Because the matching criterion can be met by multiple curve types if the average life is varied to the required precision, the method cannot be used to indicate both curve type and average life; i.e., either the curve type or average life must be specified.

This method was termed the Indicated Survivors method in the *1943 NARUC Report*. In an effort to indicate both curve shape and average life, the method was then expanded to simulate balances not just for the current year but for several test years. The simulated and actual annual balances were compared graphically.

In a presentation at an AGA-EEI conference in 1947, Alex Bauhan replaced the visual comparison of balances with the least squares criterion and called the resulting model the SPR method.[9] With the development of variations of the method focusing on retirements, Bauhan's version became known as the SPR Balances model. The mathematics of SPR are explained in the following section.

Methodology of SPR Balances Model

The SPR Balances model assumes that all vintages' additions retire in accordance with the same retirement dispersion pattern and average life. The SPR Balances model seeks to discover the type curve and average life that represent the property's retirement characteristics by retiring the vintages' additions over time according to the retirement characteristics of successive Iowa curves and noting the simulated survivors. The curves are ranked according to their ability to simulate annual survivors for the account that are close to the actual survivors for selected test years.

The simulated annual survivors for the account are calculated by simulating and summing *vintage* balances. In Table 7-8, vintage additions are multiplied by the percents surviving from an **S3-10** Iowa curve to produce the portion of additions that would still be in service if the additions had retired in accordance with the specified curve.

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[9] Bauhan, A. E., "Life Analysis of Utility Plant for Depreciation Accounting Purposes by the Simulated Plant Record Method," 1947, Appendix of the EEI, 1952.

TABLE 7-8

SIMULATION OF SURVIVORS BY SPR METHOD

Vintage	Additions	Percent Surviving **S3-10**	Simulated Survivors 12/31/95
1979	82	0.19	0
1980	160	0.94	2
1981	212	3.13	7
1982	108	7.86	8
1983	307	16.01	49
1984	237	27.75	66
1985	146	42.24	62
1986	80	57.76	46
1987	120	72.25	87
1988	222	83.99	186
1989	364	92.14	335
1990	382	96.87	370
1991	100	99.06	99
1992	207	99.81	207
1993	710	99.98	710
1994	368	100.00	368
1995	392	100.00	392
Total			2,994

The goal of the above calculation is to simulate a balance that approximates the actual balance for 1995. In actuality, survivors would be simulated for several test years using the same Iowa curve in an effort to simultaneously match the actual balance of each test year.

In order to minimize the difference between simulated and actual balances, different average lives are considered for each curve type. The selection of average lives is based upon an empirically derived relationship between the trial average lives and the sum of squared differences (SSD) between simulated and actual balances. Bauhan concluded that the SSD, calculated and graphed at various average lives for a single curve type, is parabolic (concave upwards), as shown in the sample graphs below for the **R4**, **R3**, and **R2** type curves.

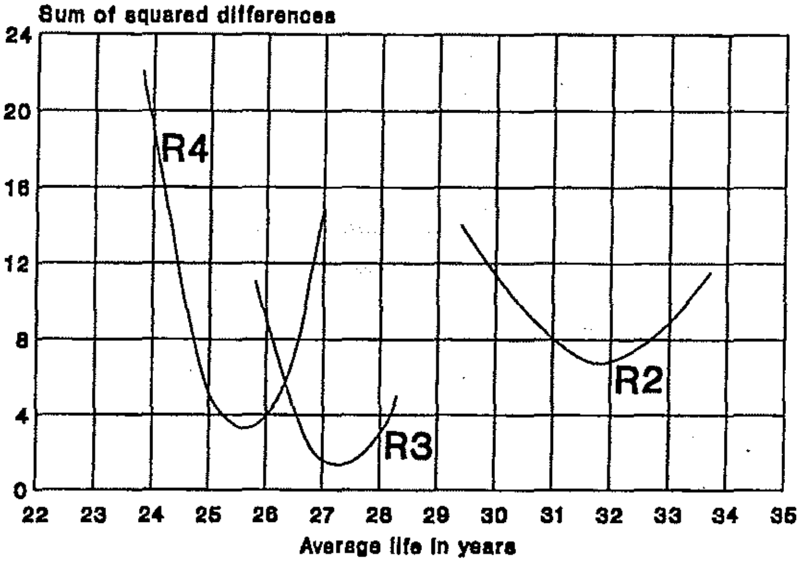

Figure 7-1. Sum of Squared Deviations Between Actual Balances and Simulated Balances for Iowa Type **R** Dispersions.[10]

This observation was useful in minimizing the trials required to arrive at the life which minimizes the SSD. Computer programs typically steadily increase or decrease the average life until the SSD begins to increase. This increase in SSD denotes that further variations of average life in the same direction would continue to increase the SSD. The computer programs will generally reverse direction and continue to test average lives until an average life close to the life associated with the minimum of the parabola is located.

Another conclusion by Bauhan concerns the relationship among curve types. After finding the optimal average life for each curve type, he graphed the resulting SSDs for each curve type. He concluded that the graphs were concave upwards within each **R**, **S**, and **L** Iowa family. Although this conclusion has been incorporated into some computer programs, exceptions have been found in many cases. That is, even though the **S2** curve may result in an SSD lower than either the **S1** or **S3** curves, use of the **S5** curve may result in a still lower SSD.

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[10] EEI, 1952, 41.

Measurements of Fit for SPR Balances Model

As mentioned earlier, Bauhan proposed the Conformance Index (CI) to rank the optimal curves.[11] The CI relates the sum of squared differences (SSD) between simulated and actual balances to the size of the account:

$$CI = \frac{average\ actual\ balance}{MSD} \tag{4}$$

$$where\ MSD\ (mean\ squared\ deviation) = \sqrt{Average\ SSD}$$

Since an SSD of zero indicates a perfect match between simulated and actual balances, a low SSD indicates that the curve has generated annual balances that are close to the actual balances. It follows that the highest ranking curves are those with the highest CIs. This relationship is shown in the arbitrary scale for the CI proposed by Bauhan:

CI	Value
over 75	excellent
50 to 75	good
25 to 50	fair
under 25	poor

The IV was developed by Ronald White and Harold Cowles.[12] It is the factored reciprocal of the CI, as shown below:

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[11] Bauhan, 1947.

[12] White, R.E. and H. A. Cowles, "A Test Procedure for the Simulated Plant Record Method of Life Analysis," *Journal of the American Statistical Association*, vol. 70 (1970): 1204-1212.

$$IV = \frac{1000}{CI} \tag{5}$$

Although the IV presently has no scale, it follows that the highest ranking curves are those with the lowest IVs. The IV, when divided by ten, approximates the average difference between simulated and actual balances expressed as a percent of the average actual balance.

The maturity of the account is measured by the REI. The REI for a specified curve is the percent of additions from the oldest vintage that would have retired by the end of the most recent test year if the additions had retired according to the retirement characteristics of the specified curve.

An REI of 100% indicates that a complete curve was used in the simulation. An REI less than 100%, say x%, indicates that a survivor curve truncated at (100-x)% surviving was used. The higher the REI, the longer the curve and, since Iowa curves become more differentiated with age, the more assurance that a unique curve pattern was used in the simulation. Bauhan proposed the following scale for the REI:

REI	Value
over 75	excellent
50 to 75	good
33 to 50	fair
17 to 33	poor
under 17	valueless

Because additions of early vintages may be insignificant with respect to their effect on test year balances, consideration has been given to modifying the REI to use the earliest *significant* vintage. Caunt proposed using the earliest vintage that had additions at least as large as 0.01% of the total gross additions for all vintages.[13]

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[13] Caunt, W. H., "Simulated Plant Record Analysis Model 1974," Paper presented at the AGA-EEI National Conference of Electric and Gas Utility Accountants, Hollywood, Florida, 1974.

Data for SPR Model

The SPR model requires a history of annual gross additions and either the annual retirements or annual balances over an extensive period of years. The history required is not as extensive for short-lived accounts since the records must extend back to include only those vintages that could have survivors at the earliest selected test year according to any trial curve.

If early additions are not available, their omission should be considered in using the SPR method. Early missing additions may be backed into using a known or estimated initial age distribution of survivors and an assumed survivor curve.

Alternatively, the survivors from the missing additions may be estimated for the selected test years using an assumed survivor curve and a known or estimated initial age distribution. These simulated survivors would be subtracted from the actual account balances to produce a series of adjusted actual balances that would be comparable to the balances simulated by SPR from the known additions. Equivalently, the estimated survivors from the missing additions could be added to the survivors simulated by SPR using the known additions to produce balances comparable to the total actual balances.

Adjustments to compensate for missing early additions may be avoided by choosing the earliest test year so that it would not include survivors from the vintages with missing additions.

Application of SPR Balances Model

When the SPR model was first developed, the simulation of balances was performed manually. In order to minimize the work effort, survivors were simulated for selected test years, e.g., every third year over a 20-year to 30-year period. The use of computers has eliminated the need to restrict the number of test years.

The selection of test periods may be likened to satisfying the objectives which are considered in actuarial analyses using experience bands. More recent bands may be chosen in order to understand the influence of recent changes. A series of successive test years may be used to reveal trends. Trends may also be detected by using "shrinking" bands, i.e., start with a large band and shrink successive bands by eliminating the earliest year of the previous band. Some analysts use "rolling" bands. For these bands, successive bands do not shrink because the year following the band is appended as the earliest year in the previous band is eliminated.

To avoid indeterminate results, the test period should be chosen so that the included vintages have experienced sufficient retirements. Test periods beginning with the inception of the account should be at least as wide as the age of the first retirements.

The results will also be indeterminate if the test years lie in a static period, i.e., one in which there is zero growth. Too few test years will result in inconclusive results. When a single test year is chosen, it is theoretically possible to find an average life that succeeds in duplicating the account balance for each curve type.

Interpreting Results of SPR Balances Model

The results of the SPR model include the CI and/or IV, which measure the fit between simulated and actual balances, and the REI, which indicates the maturity of the account. A high CI, or equivalently a low IV, indicates that the simulated balances are, on the whole, "close" to the actual balances. This is not necessarily a guarantee that the pattern used to simulate the balances matches that of the underlying data.

Bauhan states that the CI should be "good" or better (i.e., at least 50) in order for a life determination to be considered entirely satisfactory. It is not uncommon, however, for the model to produce results with low CIs for all curves over several test periods. A low CI indicates either that the account has no stable life and dispersion pattern or that the actual mortality dispersion is so unusual that it is not included in the generalized patterns that were used to simulate data. In either case, Bauhan cautions that one should be forewarned in using the results.

In some cases, the CI could be high and the result could be questionable due to insufficient experience with the account. For example, if the R3-40 curve has a high CI but the oldest vintage is only 20 years old at the end of the test period, then the simulated survivors from this earliest vintage will have been calculated using a curve truncated at 94%. As with the actuarial models, one would not want to base a conclusion on such a short curve stub. Had the earliest vintage attained an age of 50 years, the survivor curve would have extended to 18% surviving and a conclusion based on the results would be warranted.

The REI is the index that is produced to indicate the maturity of the account. The REI in the above example is 6% and 82%, respectively. According to Bauhan, results with an REI less than "fair" (i.e., less than 33%) should be discarded regardless of the CI.

In cases where early vintages have little impact on the test years' simulated balances, Bauhan advised that the REI be adjusted to use the year of the first *substantial* additions rather than the first year of additions. The effect is to produce an REI which reflects the significant portion of the curve used in the simulation.

Most SPR computer programs do not consider the significance of the installations. Some programs reflect the extent of data available for analysis by truncating the curves with the highest CI in each curve family at the age of the oldest vintage as of the end of the most recent test year. The "envelope" of curves thus created is a depiction of history. Similar to the procedure followed in matching Iowa curves to survivor curves produced by actuarial models, the analyst seeks a curve which provides a suitable extension of the truncated curves in consideration of the various factors affecting property life.

This process may result in a curve being developed which is not one of those presented on the SPR output. Bauhan anticipated this result when he advised that a curve type shown on the SPR output be coupled with an average life determined by judgment if exogenous information dictates an average life different from those presented. He also stated that it may be desirable to use a curve with a CI less than the highest if judgment does not permit the acceptance of the best fitting pattern as an estimate of the future.

Some problems may arise if the IV is calculated first and then the CI imputed. That is, in some computer programs the calculated IV is truncated to an integer and then inverted to compute the CI, as shown in Table 7-9.

TABLE 7-9

SENSITIVITY OF CONFORMANCE INDEX

Curve	IV	Truncated IV	CI
R1-11.8	2.1	2	500
L0-15.1	1.9	1	1,000

The CIs which result imply a qualitative difference in results that is not warranted. In the example above, the calculated IVs of 2.1 and 1.9 are close, demonstrating that the two curves have equivalent fits. However, the CIs of 1,000 and 500 give a specious implication that there is a qualitative difference between the fits of the curves.

Another source of problems is the failure of some SPR computer programs to consider all the curve types in a family. These programs display the first curve within a family that produces better matching balances than its "neighbors", and then the programs move on to the next family without trying to locate another curve with equally good or better balances within the family. This procedure is based upon a pattern noticed by Bauhan.[14] More recent experience indicates that the best fitting curves may fall at the beginning and end of a family, so the results from all curve types should be considered in locating the best matching curves (see Table 7-10).[15]

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[14] Bauhan, 1947.

[15] Jensen, S. D., "Examining Results of the Simulated Plant Record (Balances) Model." Paper presented at the Iowa State Regulatory Conference, Iowa State University, Ames, Iowa, 1989.

TABLE 7-10

"BEST" CURVES FALLING AT BEGINNING AND END OF A FAMILY

Curve	IV	CI	REI
S0-21.2	15	66	41
S1-16.6	17	58	60
S2-14.7	17	58	78
S3-14.1	17	58	90
S4-13.7	16	62	98
S5-13.6	15	66	100
S6-13.6	15	66	100
L0-31.2	15	66	31
L1-21.2	16	62	46
L2-16.9	17	58	64
L3-15.1	17	58	77
L4-14.1	17	58	90
L5-13.7	15	66	97
R1-26.3	14	71	28
R2-17.7	15	66	51
R3-14.7	16	62	83
R4-13.8	16	62	98
R5-13.6	15	66	100

Limitations of SPR Balances Model

As Alex E. Bauhan stated when he developed the model, the SPR model will discover the life characteristics of property when they are fairly constant or only moderately fluctuating. He assured us that "[t]he method is entirely independent of irregularities in the amount or rate of growth, and functions equally well on declining plant balances as on increasing balances." He also gave us the following warning:

> If the life and mortality dispersion characteristics have fluctuated wildly, or if the plant is immature in relation to the best fitting pattern, neither this method nor any other statistical procedure will give an answer of any prophetic merit.[16]

The model is also ineffective when applied to a test period consisting of a single year. In such case, all curves are theoretically capable of producing equally excellent results. Additionally, the model is indeterminate with respect to curve type, although not as to average life, when applied to an account that is perfectly static.

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[16] Bauhan, 1947.

Although the SPR model ages annual balances in an effort to discover the property's life characteristics, the aged data are not retained after the model has completed its calculations. Therefore, the data lack an age distribution of survivors for use in calculating accumulated depreciation guideline levels (i.e., theoretical reserve) and annual accruals using the ELG procedure or the remaining life technique.

The SPR model assumes that vintage additions are available from the inception of the account. As discussed herein, missing early additions may be estimated or successive data may be adjusted to compensate for their omission.

The SPR model has been faulted for not being readily responsive to trends. This lack of responsiveness may be due to the balances being the result of both additions and retirements, and additions may mask the changing retirements. One may avoid this "masking" by simulating retirements, as is done in the following two models.

SPR Retirements Models

The SPR Retirements models match retirements instead of balances. Like the SPR Balances model, the retirements models assume that all vintages' additions retire in accordance with the same retirement dispersion pattern and average life. The SPR Retirements models seek to discover this type curve and average life by comparing actual retirements to those simulated using different Iowa curves. The curves are ranked according to their ability to simulate retirements that are close to the actual retirements of the account for selected test years.

Several SPR Retirements models have been developed. Most notably are the Cumulative Retirements and Period Retirements variations. These models are discussed below.

A variation developed by J. F. Brennan of Pacific Gas and Electric Co. forms an equation for the survivor curve from a retirement frequency curve that is in the shape of a parabola.[17] The original model assumes that retirements begin at the early ages, although the model was later modified to include applications in which retirements begin at a later, specified age. Unlike the SPR methods, the Brennan model is not a trial and error procedure.

SPR Period Retirements Model

The SPR Period Retirements model was developed by William D. Garland while at New England Power Service Co. This model incorporates a two-step procedure.

First, for each type of retirement dispersion pattern (e.g., Iowa curve type) an average life is sought that succeeds in producing total retirements over a period of consecutive years equal to the actual retirements for the period. Retirements over a period may be computed by calculating the difference between the balances at the beginning and end of the period and adding the additions that occurred during the period.

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[17] NARUC Committee on Depreciation, 1968.

In the second step, the candidate Iowa curve types and their respective average lives developed in step one are ranked by comparing the annual simulated balances produced by each candidate curve to the actual balances for the account. The highest ranked curves are those that produce the least sum of squared differences between simulated balances and actual balances.

SPR Cumulative Retirements Model

This variation of the SPR method was developed by Henry R. Whiton of Gulf States Utilities Company. It compares the total retirements experienced by the account from inception to a given date to those simulated by the model. The cumulative retirements are calculated by subtracting the plant balance from the sum of the gross additions preceding the date of the balance. The Cumulative Retirements model produces the same results as the SPR Balances model for a given year.

Aging Property Records

Overview

When the property records do not contain the ages at which units were retired, these ages may be simulated. The Statistical Aging (STAGE) and Computed Mortality (CM) models may be used to simulate aged retirements.

The models age annual retirements (or balances) using retirement (or survival) ratios from a generalized curve (e.g., Iowa curve, Gompertz-Makeham). The aging process is performed on each year's activity in order to build an account of simulated aged data. The simulated data may then be analyzed using actuarial methods

Relationship between STAGE and CM Models

The term *statistical aging* was coined by the Interstate Commerce Commission to describe a model that would age property records using the retirement statistics of the Iowa curves. The aging of property records may also be performed using the Computed Mortality (CM) model, which permits the use of Gompertz-Makeham curves to describe retirement dispersion.

In the telecommunications industry, CM computer programs often combine the aging of property records with the *Generation Arrangement* (see Chapter IX) to produce a life indication for the account. For this reason, CM is often misinterpreted to be a life indication model rather than a data aging method. Therefore, to avoid confusion, the aging of property records is described in this chapter by referencing the STAGE model.

Methodology of STAGE Model

The STAGE model ages retirements and other activity. Aged retirements are calculated by applying retirement ratios from a generalized curve (e.g., Iowa curve, Gompertz-Makeham) to estimated or actual beginning-of-year (BOY) vintage balances. The model implicitly assumes that the retirement ratios experienced by all vintages as their property passes through the simulation year are given by a generalized curve. Activity other than retirements (e.g., transfers, acquisitions) is aged in proportion to the BOY balances.

The simulation of aged retirements is a trial and error process. Different average lives are tried with a specified curve type until vintage retirements are generated that sum to equal the total actual retirements for the simulation year.

To simulate retirements for a vintage, the vintage's simulated BOY balance is multiplied by a retirement ratio:

$$\text{BOY Vintage Balance} * \text{Retirement Ratio} = \text{Vintage Retirements} \qquad (6)$$

A retirement ratio represents the probability that property from the vintage is retired as it passes through the simulation year.

In Table 7-11, vintage balances are multiplied by the retirement ratios from an **S0** Iowa curve with a ten-year average life. The average life is then decreased and the simulation repeated in an effort to simulate retirements the sum of which equals the total actual retirements for 1993, as shown in Table 7-11.

TABLE 7-11

SIMULATING AGED RETIREMENTS

Vintage	Balance 1/1/93	S0 - 10		S0 - 8	
		Retirement Ratios	Simulated Rets (Balance *Ratios)	Retirement Ratios	Simulated Rets (Balance *Ratios)
1987	$150	0.0766	$11	0.1127	$17
1988	200	0.0657	13	0.1013	20
1989	275	0.0551	15	0.0814	22
1990	350	0.0444	16	0.0652	23
1991	500	0.0331	17	0.0417	21
1992	525	0.0199	10	0.0303	16
1993	800*	0.0035	3	0.0100	8
Total Simulated Retirements:			$85		$127
Actual Retirements:			$127		$127

* Property installed 7/1/93.

Activity other than retirements (e.g., transfers, acquisitions) may be aged in proportion to the BOY vintage balances. Aging in proportion to the BOY balances is consistent with the axiom that property subject to retirement during the period be exposed to retirement from the beginning of the period. As shown in Table 7-12, the ratio of a vintage's BOY balance to the total annual BOY balance is multiplied by the amount to be allocated (e.g., 200 in Table 7-12) in order to calculate the portion to be allocated to the vintage.

TABLE 7-12

ALLOCATING OTHER ACTIVITY

Vintage	Balance 1/1/93	Proportion (Vintage Balance /Total Balance)	Allocation (Proportion * 200)
1987	$ 150	0.0750	$15
1988	200	0.1000	20
1989	275	0.1375	28
1990	350	0.1750	35
1991	500	0.2500	50
1992	525	0.2625	53
Totals	$2,000		$200

Alternatively, each vintage's portion of the total other activity may be calculated by first finding the ratio of the total other activity to the account's surviving balance at the beginning of the year and multiplying each vintage's BOY balance by this quotient. In the above example, the ratio of total other activity to the account's BOY balance is $200/$2,000. It follows, then, that each vintage's portion of the $200 in other activity is 10% of the vintage's BOY balance.

Data for STAGE Model

The STAGE model requires an initial age distribution of survivors and, for each successive year, the additions and either the total account retirements or balances. If the additions for vintages prior to the initial year are available, the initial distribution may be calculated by the Indicated Survivors method.[18] In this variation of the SPR model, percents surviving from a survivor curve are multiplied by the vintages' additions. The average life is varied for the specified curve shape until vintage survivors at the initial year are simulated that sum to equal the actual account balance for the initial year.

If the prior year's vintage additions are not available, an alternative method must be used, such as sampling the property records. The sensitivity of the results to the initial distribution depends upon the number of years of activity after the initial distribution in relation to the average life of the property. Thus, the initial distribution is less important for short-lived accounts for which there is a number of years' activity.

If the decision has been made to keep aged records from the present forward, the STAGE model may be used to simulate aged data for the preceding years. Likewise, if the

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[18] Hill, C. G., "Depreciation of Telephone Plants, Part I," *Telephony*, vol. 82, no. 11, 12-16 (March 18, 1922).

decision is to cease keeping aged records, data simulated by the STAGE model may be appended to actual aged data.

The STAGE model requires that the curve shape be specified. Iowa curves, New York h curves, or curves described by the Gompertz-Makeham equation are appropriate since the lives may be varied in the simulation. The selection of a curve shape is discussed below.

Selecting a Curve Shape

From the STAGE calculations, it can be seen that the mathematics used to simulate retirements is the reverse of that used in the retirement rate actuarial method. Specifically, the actuarial method calculates retirement ratios using vintage retirements in an effort to select generalized curves (e.g., Iowa curves). Conversely, the STAGE model uses retirement ratios from generalized curves in an effort to calculate vintage retirements. The relationship between these two methods reveals that the curve that should be used with the STAGE model is the one which would result from a one-year experience band in a retirement rate actuarial analysis.

Since there are several curve-shape-life combinations which produce aged retirements to equal the total actual retirements, either the curve shape or the average life must be specified. Typically, the models require that the curve shape be stated.

The selection of curve shape is based on informed judgment and familiarity with the property being analyzed. Although the SPR model has often been used to indicate a dispersion pattern, the application of the SPR model to accounts with varying life characteristics is ill advised, as noted earlier.

In lieu of using the SPR model, one may consider using the curve shape indicated by actuarial analyses of actual aged data for an account with similar characteristics. If these data have not been maintained, a statistical sample of activity could be made. Consideration could also be given to the curve shapes developed by companies which have maintained aged data for similar property subject to similar forces of retirement.

It may be possible to develop an appropriate curve shape from knowledge of the causes of retirement. For example, retirements which are all planned to occur at a given age are depicted by an **SQ** (square) survivor curve. Property subject to significant infant (early age) mortality is described by low subscripted **L** (left modal) curves. The **L** curves are also associated with property groups containing property surviving significantly beyond the group's average life.

Retirements due to chance are represented by the negative exponential curve, which is similar to the **O2** Iowa curve. Retirements that are equally distributed around an average would be described by a curve from the **S** family.

The curve shape selection may be judged for reasonableness by evaluating the model's results. One result to be evaluated is the reasonableness of the average life used to simulate aged retirements. Another result to be considered is the extent to which there are vintage survivors to which no retirement ratios are being applied because the vintages exceed the maximum life of the curve used in the simulation. Different curve shapes could be tested in an effort to produce more reasonable results.

As noted above, the curve sought by STAGE is the one which would result from a one-year experience band in a retirement rate actuarial analysis. Just as the indicated curves may vary from one experience band to the next for some accounts, it is mathematically appropriate that different curve shapes be used for different simulation years for accounts with varying life characteristics.

Interpreting the Results of STAGE Model

Each year, the STAGE model is used to age the year's retirements and other activity. The aged data are combined with previously simulated data to create an aged database suitable for analysis using actuarial methods.

As discussed earlier, each year that data are simulated, an average life is calculated. Mathematically it can be seen that these annual lives are the same as those that would be produced by successive one-year experience bands in actuarial analyses using the specified curve shape. As in actuarial analyses, the lives may be analyzed for trends. In the telecommunications industry, the series of these lives is referred to as a *worm curve*.

These annual life indications may be somewhat erratic from year to year. The variations may be due to fluctuations in retirement levels or to the use of a constant curve shape from year to year whereas in reality the curve shape may be variable. It may be advisable, therefore, to consider the average of the annual life indications over three to five years.[19]

Another outcome of the model is the production of an age distribution of survivors at the end of the latest year. This distribution is useful in cases where vintage data are required, such as in theoretical reserve studies and remaining life depreciation calculations.

Advantages

A distinct advantage of the STAGE model is its ability to allow life characteristics to vary by experience year and by vintage. The variation by vintage results from the change in average life (and curve shape, if desired) from one simulation year to the next. By contrast, the SPR model assumes that all vintages share the same curve shape and average life.

Unlike the SPR model, the STAGE model does not use the original vintage additions once the data have been initialized. The original additions may not even be required in the initialization process if sampling or other methods are available to estimate the initial age distribution. Thus, STAGE is not subject to the problems the SPR model has when early additions are missing.

Another use of the STAGE model is in the supplying of temporary records. The model may produce simulated aged data prior to final accounting, after which the simulated data are replaced by actual amounts.

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[19] Carver, Lynda B., "Computed Mortality," *Journal of the Society of Depreciation Professionals* vol. 1, no. 1 (1989).

STAGE may also be used to price annual retirements. The units retired during the simulation year are aged by the model and then priced according to the vintage unit costs.

The STAGE model also produces an age distribution of survivors at the end of the latest year for use in applications such as theoretical reserve studies and remaining life calculations.

Limitations

As discussed above, the aging of annual activity begins with an initial age distribution of survivors. The development of the initial age distribution may be a problem if the vintage additions that would most likely contribute to the initial age distribution are not available.

A common complaint about the STAGE model is that it does not provide an indication of curve shape; instead, the curve shape must be specified. The use of the SPR model to assist in developing a curve shape is popular but may distort the STAGE results if the SPR model is applied to accounts for which the assumptions of the SPR model are not satisfied. It is suspected that specifying curve shape may be tantamount to predetermining the results.

CHAPTER VIII

ACTUARIAL LIFE ANALYSES

Knowing what happened yesterday may help one to better understand what is happening today and what may happen tomorrow. This is also true with depreciation studies. Historical life analysis is the study of past occurrences that may be used to indicate the future survivor characteristics of property. Accumulation of suitable data is essential in an historical life analysis. As discussed in the previous chapter, the detail available in the data determines the kinds of analyses (actuarial v. simulation) that can be performed. Understanding the data is necessary in order to assess the limitations and application of the data in reflecting future events. Informed judgment plays a major role in determining how the data should be interpreted and used.

Actuarial analysis is the process of using statistics and probability to describe the retirement history of property. The process may be used as a basis for estimating the probable future life characteristics of a group of property.

Actuarial analysis requires information in greater detail than do other life analysis models (e.g., turnover, simulation) and, as a result, may be impractical to implement for certain accounts (see Chapter VII). However, for accounts for which application of actuarial analysis is practical, it is a powerful analytical tool and, therefore, is generally considered the preferred approach.

Actuarial analysis objectively measures how the company has retired its investment. The analyst must then judge whether this historical view depicts the future life of the property in service. The analyst takes into consideration various factors, such as changes in technology, services provided, or capital budgets.

Mortality History

The purpose of actuarial analysis is to analyze the life characteristics of the utility's property using the historical data contained in the Continuing Property Records (CPR) (see Chapter III). In order to be used in actuarial analyses, the database must contain the property's year of installation (i.e., vintage) and year of retirement. Since the property records are maintained primarily for purposes other than depreciation studies (e.g., for capital budgeting or to accurately reflect a utility's plant), they may require adjustment before use in a depreciation study.

The Treatment of Adjustments and Transfers

The company's property records may contain adjusting entries and transfers (see Chapter III). In the treatment of these adjustments and transfers for preparing life tables, all plant exposed to the forces of retirement at any time during the age interval must be included as an exposure at the beginning of the age interval.

The retirement ratio can be used to depict history or to forecast future activity. These contexts require two differing approaches to the handling of transfers, accounting errors, and adjustments. These two concepts are discussed separately below.

Depiction of History

When determining whether a particular accounting entry is to be included in either exposures or retirements, the criterion is whether the data accurately represent history. The analyst should remember that accurately representing the history of the physical asset may be different from accurately representing the history of the investment. Unusual retirements, or retirements based on outdated accounting methods (i.e., changing of the capitalization threshold), should not be adjusted when the goal is to restate history, as long as those retirements accurately reflect the history.

Conversely, items such as accounting errors, which misstate the history of the investment under study, should be adjusted. For example, assume a retirement in an activity year (year 1) is made from the wrong vintage (vintage A, where the correct vintage is B) and is corrected in a subsequent activity year.

The correction includes the following steps:

1. Excluding the retirement from vintage A in activity year 1 and restating the closing balance in activity year 1 and all subsequent activity years, for that vintage, and

2. Making the retirement in vintage B in activity year 1 and restating the closing balance in activity year 1 and all subsequent activity years, for that vintage.

Forecast of Future Activity

In general, historical data used to forecast future retirements should not contain events that are either anomalous or unlikely to recur. Therefore, in making adjustments to the data, the analyst must consider the purpose of the analysis. Often the same data and the same analysis will be used both as a statement of history and as a basis for forecasting.

A sizable benefit may be obtained for a relatively minor incremental cost if the general principles are adhered to in the initial data collection phase. This is particularly true because the time required to appropriately adjust the data benefits both the current study and all future studies.

Despite the benefits of collecting good data, often the decision is made to proceed with the data "as is." In these instances, the analyst must keep in mind the nature of any transfers, anomalies, or adjustments present in the data; how they may affect the result; and how the result of the analysis is going to be used.

Retirements Subject to Reimbursement

Retirements may be subject to reimbursement from various sources. For example, wood poles in either the telephone or electric industries may be retired subject to reimbursement from an insurance company (e.g., a pole damaged by an automobile) or the government (e.g., a line of poles that must be retired due to street or highway work). Depending on the accounting treatment for reimbursements related to retired property, the analyst may need to remove such plant from the database. If the reimbursement is recorded as salvage, no adjustment of retirement data would be necessary, assuming that such salvage is also considered in establishing future depreciation rates. Consistent treatment is the rule.

Banding

Banding is the compositing of a number of years of data in order to merge them into a single data set for further analysis. Often, several bands are analyzed. By making determinations of the life and retirement dispersion indicated in successive bands, the analyst can get a clear indication of whether there is a trend in either the life of the plant or in the dispersion of the retirements.

In general, there are three reasons to use bands:

1. *Increase the sample size*. In statistical analyses, the larger the sample size in relation to the universe (the body of all data), the greater the reliability of the result (i.e., the greater the probability that the results will be applicable to the universe as a whole).
2. *Smooth the observed data.* Generally, the data obtained from a single activity or vintage year will not produce an observed life table that can be easily fit.
3. *Identify trends.* By looking at successive bands, the analyst may identify broad trends in the data that may be useful in projecting the future life characteristics of the property.

The following sections discuss placement bands and experience bands, as well as different types of bands—rolling, shrinking, and fixed.

Placement Bands

Placement bands show, for a group of vintages, the composite retirement history from the property's placement in service to the present. Placement bands allow the analyst to isolate the effects of changes in technology and materials that occur in successive generations of plant. For example, consider a telephone company that installed air-core buried cable before a given year and jelly-filled cable thereafter. In order to identify the differences in service life and retirement dispersion between the two types of cable, one might want to look at a placement band consisting of all vintages prior to the changeover and a second band of all vintages after the changeover.

An advantage of placement bands is that they generally yield smooth curves when based on fairly narrow bands. Unfortunately, placement bands yield fairly complete curves only for the oldest vintages. The newest vintages, presumably of greater interest in forecasting, yield the shortest stub curves.

Experience Bands

Experience bands show the composite retirement history for all vintages during a select set of activity years. These bands allow the analyst to isolate the effects of the operating environment over time.

Experience bands yield the most complete curves for the recent bands because they have the greatest number of vintages (ages) included. However, they may require significant smoothing because the data for each age is independent of the data for other ages. This independence can result in an erratic retirement dispersion.

Experience bands require that during the experience band, in order to construct an observed life table, at least one vintage in the band must be at age zero.

Types of Bands

There are several ways to select placement and experience bands. Rolling bands and shrinking bands may be useful in identifying trends in the data. These bands, along with fixed bands, are discussed below.

Rolling. To set up rolling bands, the analyst selects beginning and ending years for the initial band. The second band has beginning and ending points x years (usually one year) later than those of the first band; the third band has beginning and ending points each x years (usually one year) later than those of the second band; and so on. The result is a series of "rolling" bands of identical width as shown in the sample three-year rolling bands below:

Band 1:	1990	1991	1992		
Band 2:		1991	1992	1993	
Band 3:			1992	1993	1994

Rolling bands are useful in isolating and identifying the effects of specific events or changes that affect the life and retirement dispersion of the plant. However, rolling placement bands have the disadvantage of producing short observed life tables for recent placement bands.

Shrinking. To set up shrinking bands, the analyst selects a wide band (often the band is much wider than would be used for any other type of banding). Generally, the last year in the band is the most recent year of data. Successive bands are derived by dropping one or more years from the beginning of the band.

The advantage of shrinking bands anchored at the most recent year is that all of the resulting bands contain the most recent data. Each successive band more strongly reflects the effect of the more recent data. This is especially useful with placement bands, for which the more recent bands result in shorter survivor curves.

Fixed. Fixed bands are generally of a selected width and are nonoverlapping. They are often selected in order to investigate the impact of certain events on the company's property. They are less useful than rolling and shrinking bands in revealing trends. However, fixed bands generate a more manageable number of bands to review.

Selection of Bands and Band Width

The analyst must select a band width (number of activity years to include in the band) which meets two, often conflicting, constraints: (1) The band must include enough data to provide some confidence in the reliability of the resulting curve fit; and (2) the band must be narrow enough that an emerging trend can be observed. Bands of three to five years are often chosen for rolling or fixed bands. However, for longer life plant (e.g., conduit), widths of ten or more years may be necessary.

The Observed Life Table Exhibit

The observed life table exhibit (Table 8-1) presents the exposures, retirements, retirement ratio, survival ratio, and life table values (percent surviving) for each age interval. To illustrate

TABLE 8-1

OBSERVED LIFE TABLE EXHIBIT

Band 1992 - 1994

Age	Exposures	Retirements	Retirement Ratio	Survival Ratio	Observed Life Table
(A)	(B)	(C)	(D)=(C)/(B)	(E)=1 - (D)	$(F)_{(x)}=F_{(x-1)}*E_{(x-1)}$
0	4,843,776	9,705	0.00200	0.99800	100,000
0.5	4,761,957	23,810	0.00500	0.99500	99,800
1.5	5,298,919	52,989	0.01000	0.99000	99,301
2.5	5,825,563	87,383	0.01500	0.98500	98,308
3.5	6,462,684	129,254	0.02000	0.98000	96,833
4.5	4,343,837	108,596	0.02500	0.97500	94,896
5.5	3,145,870	94,376	0.03000	0.97000	92,524
6.5	2,309,272	80,825	0.03500	0.96500	89,748
7.5	2,864,124	114,565	0.04000	0.96000	86,607
8.5	2,294,969	103,274	0.04500	0.95500	83,143
9.5	1,695,740	84,787	0.05000	0.95000	79,401
10.5	725,080	39,879	0.05500	0.94500	75,431
11.5	585,138	35,108	0.06000	0.94000	71,283
12.5	449,968	29,248	0.06500	0.93500	67,006
13.5	369,726	25,881	0.07000	0.93000	62,650
14.5	309,333	23,200	0.07500	0.92500	58,265
15.5	340,553	27,244	0.08000	0.92000	53,895
16.5	289,195	24,582	0.08500	0.91500	49,583
17.5	188,651	16,979	0.09000	0.91000	45,369
18.5	49,802	4,731	0.09500	0.90500	41,285
19.5					37,363
Total All	47,154,157	1,116,416			1,482,691

the development of the observed life table values, a sample chart "Summary of Historical Mortality Data" (Table 8-2) containing both exposures and retirements for each vintage from 1975 to 1994 is used. For each vintage, the investment exposed to retirement at the beginning of each age interval is shown on the same line as the year placed. On the following line, the vintage's retirements during each age interval are shown.

The half-year convention is used in Table 8-2. Retirements that occurred between age 0.0 and 0.5 years are shown under the heading N=0. Retirements that occurred between age 0.5 and 1.5 years, and the exposures that are 1.5 years old at the end of the age interval, are shown under the heading N=1, and so on. Using the half-year convention, the first age interval (N=0) has a width of 0.5 years from age 0.0 (a new installation) to age 0.5 (the end of the calendar year in which the plant entered service). Later age intervals have a width of one year.

Consider a three-year experience band for the years 1992 through 1994. The plant exposures and retirements for this band form a diagonal strip with a width of three years through Table 8-2 ascending from the lower left to the upper right (see the data between the two double lines).

The exposures and retirements for the 1992-1994 band are summed by age interval and depicted at the bottom of Table 8-2. The data at each age relates to the activity years 1992, 1993, and 1994, as explained below:

Age 0:	The exposures ($4,843,776) represent plant added in 1992 through 1994, and the retirements ($9,705) represent the amount of these additions retired between 1992 and 1994 (i.e., in the same year in which they were placed).
Age 1:	The exposures ($4,761,957) represent plant added in 1991 through 1993 that is surviving one year after placement. The retirements ($23,810) represent the amount of these additions retired between 1992 and 1994 (i.e., one year after placement).
Age 2:	The exposures ($5,298,919) represent plant added in 1990 through 1992 that is surviving two years after placement. The retirements ($52,989) represent the amount of these additions retired between 1992 and 1994 (i.e., two years after placement), and so on.

Once the exposures and retirements by age interval have been developed for a band, the retirement ratios, survival ratios, and life table values (percents surviving) are calculated. The retirement ratio for an age interval is calculated by dividing the retirements during the age interval by the exposures at the beginning of the age interval. The survival ratio is one minus the retirement ratio. The percent surviving at the end of an age interval is calculated by multiplying the percent surviving for the previous age interval by the survival ratio for the current age interval. The observed life table begins with a value of 100% (or 1.0) at age zero.

TABLE 8-2
SUMMARY OF HISTORICAL MORTALITY DATA

Year Placed	Total Amount of Plant Placed	Total Amount of Plant Retired	Total Amount of Plant Still in Service	Nth Year After Year of Placing UPPER FIGURES: Plant Remaining in Service At Beginning of Nth Calendar Year After Year of Placing LOWER FIGURES: Plant Retired During Nth Year After Year of Placing							
				N = 0	1	2	3	4	5	6	7
1975	120,672	75,601	45,071	-	120,387	119,785	118,587	116,808	114,472	111,610	108,262
				285	602	1,198	1,779	2,336	2,862	3,348	3,789
1976	295,287	173,417	121,870	-	294,597	293,124	290,193	285,840	280,123	273,120	264,926
				690	1,473	2,931	4,353	5,717	7,003	8,194	9,272
1977	167,490	91,528	75,962	-	167,098	166,263	164,600	162,131	158,888	154,916	150,269
				392	835	1,663	2,469	3,243	3,972	4,647	5,259
1978	169,323	85,397	83,926	-	168,923	168,078	166,398	163,902	160,624	156,608	151,910
				400	845	1,681	2,496	3,278	4,016	4,698	5,317
1979	194,280	89,609	104,671	-	193,825	192,856	190,927	188,063	184,302	179,695	174,304
				455	969	1,929	2,864	3,761	4,608	5,391	6,101
1980	226,742	94,676	132,066	-	226,212	225,081	222,830	219,488	215,098	209,720	203,429
				530	1,131	2,251	3,342	4,390	5,377	6,292	7,120
1981	250,743	93,705	157,038	-	250,156	248,905	246,416	242,720	237,866	231,919	224,961
				587	1,251	2,489	3,696	4,854	5,947	6,958	7,874
1982	343,663	113,468	230,195	-	342,858	341,144	337,732	332,666	326,013	317,863	308,327
				805	1,714	3,411	5,066	6,653	8,150	9,536	10,791
1983	367,167	105,531	261,636	-	366,306	364,474	360,830	355,417	348,309	339,601	329,413
				860	1,832	3,645	5,412	7,103	8,708	10,188	11,529
1984	1,423,589	348,641	1,074,948	-	1,422,214	1,415,103	1,400,952	1,379,938	1,352,339	1,318,530	1,278,974
				1,375	7,111	14,151	21,014	27,599	33,808	39,556	44,764
1985	968,495	199,759	768,736	-	966,225	961,394	951,780	937,503	918,753	895,784	868,911
				2,270	4,831	9,614	14,277	18,750	22,969	26,874	30,412
1986	914,111	154,353	759,758	-	911,969	907,409	898,335	884,860	867,163	845,484	820,119
				2,142	4,560	9,074	13,475	17,697	21,679	25,365	28,704
1987	691,326	92,793	598,533	-	689,706	686,257	679,395	669,204	655,820	639,424	620,242
				1,620	3,449	6,863	10,191	13,384	16,395	19,183	21,708
1988	1,794,969	183,836	1,611,133	-	1,791,573	1,782,615	1,764,789	1,738,317	1,703,551	1,660,962	1,611,133
				3,396	8,958	17,826	26,472	34,766	42,589	49,829	
1989	2,091,388	156,534	1,934,854	-	2,087,003	2,076,568	2,055,802	2,024,965	1,984,466	1,934,854	
				4,385	10,435	20,766	30,837	40,499	49,612		
1990	2,786,937	141,523	2,645,414	-	2,782,102	2,768,191	2,740,510	2,699,402	2,645,414		
				4,835	13,911	27,682	41,108	53,938			
1991	1,047,328	33,516	1,013,812	-	1,044,872	1,039,648	1,029,251	1,013,812			
				2,456	5,224	10,396	15,439				
1992	1,501,303	25,134	1,476,169	-	1,498,573	1,491,080	1,476,169				
				2,730	7,493	14,911					
1993	2,222,862	15,443	2,207,419	-	2,218,512	2,207,419					
				4,350	11,093						
1994	1,119,611	2,625	1,116,986	-	1,116,986						
				2,625							
TOTAL	18,697,286	2,277,085	16,420,201								

Three-Year Bands		Age of Plant Remaining January 1 of any year							
		0.0	0.5	1.5	2.5	3.5	4.5	5.5	6.5
1992-1994	Exposures	4,843,776	4,761,957	5,298,919	5,825,563	6,462,684	4,343,837	3,145,870	2,309,272
Between = = Lines	Retirements	9,705	23,810	52,989	87,383	129,254	108,596	94,376	80,825

TABLE 8-2 (continued)
SUMMARY OF HISTORICAL MORTALITY DATA

Year Placed	Nth Year After Year of Placing UPPER FIGURES: Plant Remaining in Service At Beginning of Nth Calendar Year After Year of Placing LOWER FIGURES: Plant Retired During Nth Year After Year of Placing												
	8	9	10	11	12	13	14	15	16	17	18	19	20
1975	104,473	100,294	95,781	90,992	85,987	80,828	75,574	70,284	65,013	59,812	54,728	49,802	45,071
	4,179	4,513	4,789	5,005	5,159	5,254	5,290	5,271	5,201	5,084	4,925	4,731	
1976	255,654	245,428	234,384	222,664	210,418	197,793	184,936	171,991	159,091	146,364	133,923	121,870	
	10,226	11,044	11,719	12,247	12,625	12,857	12,946	12,899	12,727	12,441	12,053		
1977	145,009	139,209	132,944	126,297	119,351	112,190	104,897	97,555	90,238	83,019	75,962		
	5,800	6,264	6,647	6,946	7,161	7,292	7,343	7,317	7,219	7,057			
1978	146,593	140,729	134,396	127,677	120,654	113,415	106,043	98,620	91,224	83,926			
	5,864	6,333	6,720	7,022	7,239	7,372	7,423	7,397	7,298				
1979	168,203	161,475	154,209	146,498	138,441	130,134	121,676	113,158	104,671				
	6,728	7,266	7,710	8,057	8,306	8,459	8,517	8,487					
1980	196,309	188,456	179,976	170,977	161,573	151,879	142,007	132,066					
	7,852	8,481	8,999	9,404	9,694	9,872	9,940						
1981	217,088	208,404	199,026	189,075	178,676	167,955	157,038						
	8,684	9,378	9,951	10,399	10,721	10,917							
1982	297,535	285,634	272,780	259,141	244,889	230,195							
	11,901	12,854	13,639	14,253	14,693								
1983	317,884	305,168	291,436	276,864	261,636								
	12,715	13,733	14,572	15,228									
1984	1,234,210	1,184,842	1,131,524	1,074,948									
	49,368	53,318	56,576										
1985	838,499	804,959	768,736										
	33,540	36,233											
1986	791,415	759,758											
	31,657												
1987	598,533												
1988													
1989													
1990													
1991													
1992													
1993													
1994													
TOTAL													
3-year bands	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	
1992-1994	2,864,124	2,294,969	1,695,740	725,080	585,138	449,968	369,726	309,333	340,553	289,195	188,651	49,802	
between==	114,565	103,274	84,787	39,879	35,108	29,248	25,881	23,200	27,244	24,582	16,979	4,731	

The calculations discussed above are summarized below:

1. Retirement Ratio for age interval (n):
   $\text{Retirement Ratio}_n = \text{Retirements}_n / \text{Exposures}_n$

2. Survival Ratio for age interval (n):
   $\text{Survival Ratio}_n = 1 - \text{Retirement Ratio}_n$

3. Percent Surviving at end of age interval (n):
   $\text{Percent Surviving}_n = \text{Percent Surviving}_{n-1} \times \text{Survival Ratio}_{n-1}$

Curve Fitting Techniques

Plotting the Survivor Curve

Although the analyst may find it helpful to plot the retirement ratios and survival ratios from the observed life table, generally, the percents surviving are plotted. These points may be connected to form an observed survivor curve as shown in Figure 8-1. The most common difficulties in using this curve are discussed in the following sections.

Stub Curve

An observed survivor curve that does not reach 0% surviving is a stub. Because the average life associated with a survivor curve is represented by the area under the *complete* curve, the observed survivor curve must be smoothed and extended to 0% surviving, as discussed later in this chapter. The longer the stub, the more reliable the resulting curve fit and extension. As a result, the analyst may be forced to choose between a more reliable longer stub, which by necessity reflects older data, and a less reliable shorter stub, which reflects more recent vintages and, therefore, is more likely to reflect the future.

It is generally considered desirable to have the stub curve drop below 50% surviving. It is understood, however, that this is not always possible since some accounts have so few retirements that none of the placement or experience bands produces survivor curves that meet this test.

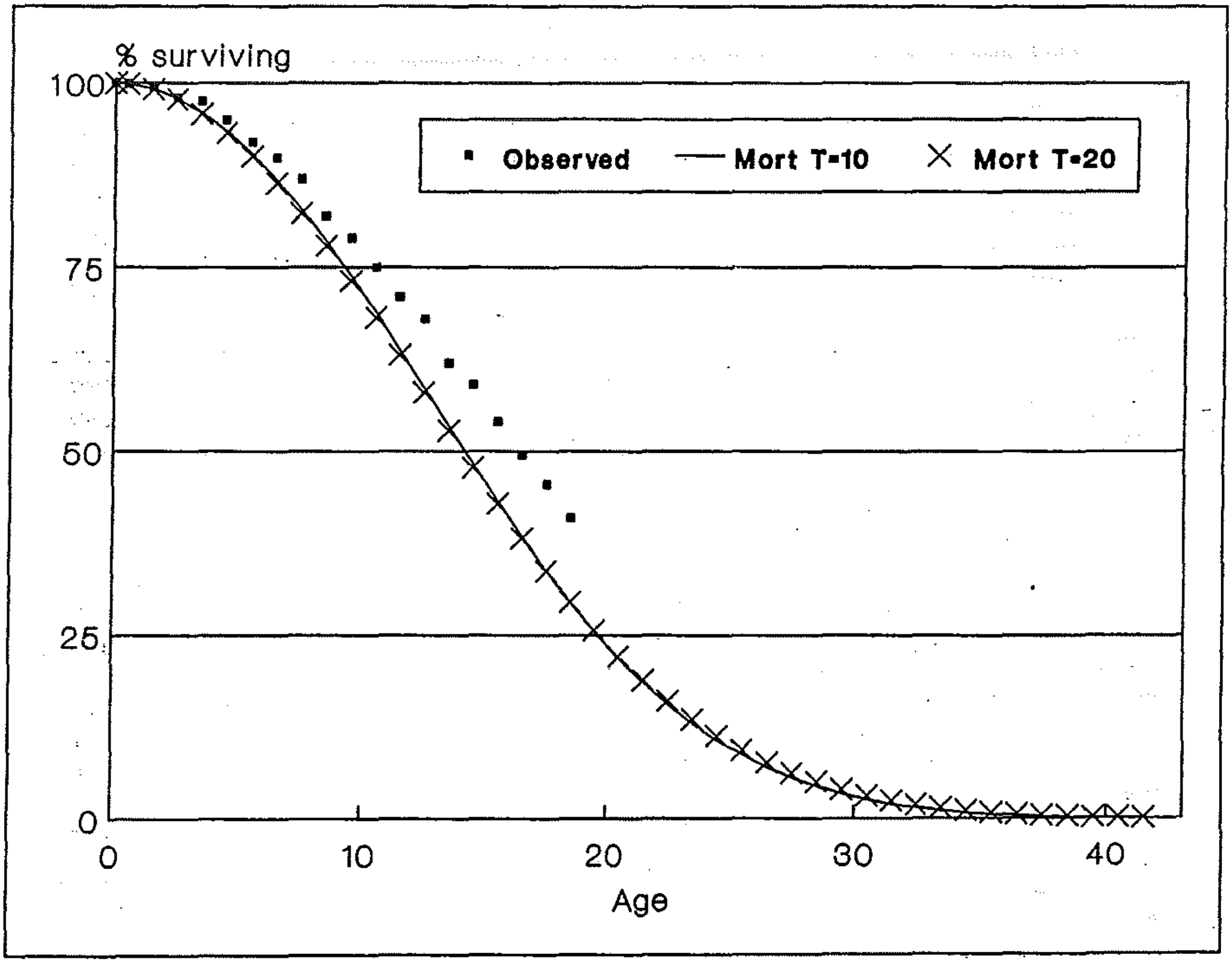

Fig. 8-1 Comparison of Observed Data and Graduated Survivor Curves.

Data Irregularities

Property that exhibits homogenous life characteristics produces smooth survivor curves. Many of a utility's property accounts, however, have experienced change in the forces of retirement due to, for example, changes in a utility's services or capital budgets. These accounts may exhibit a number of irregularities. For example, the survivor curves may look like stair steps as the different changes take effect. Extended leveling-off periods may result from reasons such as delayed booking of retirements during an accounting system conversion. Irregularities at the older ages of the survivor curve often result from inadequate exposures.

Bimodality. Bimodality, the presence of two peaks on the retirement frequency curve, was once considered to be a new curve shape. Later study, however, revealed that bimodality results from superimposing two distinct retirement frequency curves, each with its own mode. This results from a lack of homogeneity in the property, such as occurs when low-volume and high-volume gas meters with different retirement dispersions are included in one account.

Bimodality should be investigated by attempting to separate the two groups by either selecting different placement or experience bands (assuming the lack of homogeneity is due to differences in technologies or environments over time) or segregating the raw data (as would be required in the above gas meters example). Minor stair steps or flat areas of curves may be ignored. Where appropriate, significant occurrences should be removed from consideration either through the selection of different bands or through the use of a Truncation-cut (T-cut).

T-cuts. A T-cut is a truncation of the observed life table values and is generally used in a mathematical fitting of a curve to the observed values. A T-cut is used to mathematically perform a function that is automatic in visual fitting (i.e., setting a point beyond which the observed data are considered irrelevant or unreliable and are, therefore, ignored).

Careful selection of a T-cut can greatly enhance the reliability of the resulting analysis. Conversely, since the use of a T-cut involves truncating the observed data, careless selection can impair the reliability of subsequent work.

In Figure 8-1, two different "best fits" of Gompertz-Makeham curves based on the least sum of squared deviations are shown. The difference between the two best fits is that one is based on the entire observed survivor curve and the other has a T-cut established at 13 years. The location of the T-cut can affect the resulting best fit curve. By excluding only a few ages by a T-cut, the shape and remaining life of the best fit curve may change.

The use of a T-cut can also have an adverse effect on reliability by creating a stub curve. The observed survivor curve at the early ages fits a large number of curves. This is particularly true where the mode of the retirement frequency curve is greater than the average life (i.e., the majority of retirements occur at later ages).

Both of the problems mentioned above are exacerbated when the T-cut occurs near the mode of the retirement frequency curve, i.e., the steepest portion of the survivor curve. Therefore, T-cuts near or at the mode of the retirement frequency curve should be avoided.

The following methods are generally used to smooth irregularities in the observed data or to extend a curve where data are lacking: (1) smoothing and extending the observed life table values, (2) smoothing and extending the retirement frequency curve, (3) smoothing and extending the retirement ratio curve, and (4) matching generalized survivor curves to the observed life table values. Each of these methods is discussed briefly below.

1. Smoothing and Extending the Observed Life Table Values

The Gompertz-Makeham formula, originally developed in connection with studies of human mortality, may be used to smooth and extend the observed life table values. The Gompertz-Makeham formula is:

$$1_x = k * s^x * g^{c^x} \qquad (1)$$

where l_x is the number surviving at age x

The parameters k, s, g, and c are derived from the data in the observed life table. For further discussion of the derivation and application of the Gompertz-Makeham formula, see Appendix A, part 1.

2. Smoothing and Extending the Retirement Frequency Curve

This method is seldom used today. It is discussed to a limited degree in both the *1943 NARUC Report* and the *1968 NARUC Manual.*

3. Smoothing and Extending the Retirement Ratios

The Exposure-Weighted Gompertz-Makeham method graduates the observed mortality ratios, rather than the percents surviving, to determine the best fit. This application of the Gompertz-Makeham formula is mathematically superior to the original unweighted formula because retirement ratios are independent of observations at prior ages. The method is explained in detail in Appendix A, part 2.

There is another method of smoothing and extending the retirement ratios that predates the Exposure-Weighted Gompertz-Makeham method and has been in use for many years. This method is referred to simply as "smoothing the retirement ratios." It involves fitting a smooth curve to the observed retirement ratios and then extending the curve. The extended fitted curve is used to develop the smoothed survivor curve. Originally, an unweighted fit to the retirement ratios was used but a weighted fit process was later developed. This method is also further discussed in Appendix A, part 4.

4. Matching Generalized Curves to the Observed Life Table Values

In lieu of using mathematical models to smooth and extend the observed percents surviving, one may match generalized curve shapes to the observed life table values.

Iowa Curves. Probably the most widely used of the standard curve sets, the Iowa curves were originally conceived by Edwin Kurtz and developed by Robley Winfrey. They may be found in *Bulletin 125* published by the Iowa Engineering Station (now the Engineering Research Institute) of Iowa State University. Based on empirical analyses of the retirement histories of various forms of utility, railroad, industrial, and agricultural equipment, Winfrey derived three general classes of curves—L, S, and R. Frank Couch, Industrial Engineering Department, Iowa State University, expanded the family of Iowa curves by adding the O curves.

Bell Curves. The Bell curves, developed by the Bell telephone companies, are standardized Gompertz-Makeham curves and are largely used only in the telephone industry. Each Bell curve (from 0.0 through 5.5) has a set of c, G, and S values.

h Curves. The h curves, published in 1947, were developed by Bradford Kimball of the New York Public Service Commission staff. They are based on a normal statistical distribution of retirements (bell-shaped curve), with the tail truncated at various standard deviations.

For a more detailed discussion of generalized curves, see Appendix A, parts 3 and 5.

Visual Matching

Graphs of the various standard curves are available. While visual matching is still used, it is more time consuming than mathematical matching and so is generally used only in educational settings or as an adjunct to mathematical matching.

First, the observed life table is plotted to the same scale as one of the available published overlays. Successive overlays are then applied to the plotted survivor curve until a good correlation between the observed data points and the published curve is noted. An experienced eye can often cut this process short by eliminating certain classes of standard curves. Elimination is based on the appearance of the observed data once plotted. High resolution computer graphics have automated the visual matching process.

Mathematical Matching

Without the use of computers, mathematical matching would be impractical due to the number of calculations involved in determining the goodness of fit of a single curve. Since the Bell curves are essentially Gompertz-Makeham curves, the mathematical matching proceeds similarly for both types of curves. For the Iowa and h curves, mathematical matching consists of comparing the observed data to standard tables of the percent surviving at each age and calculating the goodness of fit between the observed data and the standardized curves.

Generally, the goodness of fit criterion is the least sum of squared deviations. The difference between the observed and projected data is calculated for each data point in the observed data. This difference is squared, and the resulting amounts are summed to provide a single statistic that represents the quality of the fit between the observed and projected curves.

The difference between the observed and projected data points is squared for two reasons:

(1) the importance of large differences is increased, and (2) the result is a positive number, hence the squared differences can be summed to generate a measure of the total absolute difference between the two curves. The curves with the least sum of squared deviations are considered the best fits. The intent is not to select the one *best* curve but to consider the indicated patterns.

Interpreting the Results

Once data assembly and property grouping have been completed, the next step is to determine how to use this information. Several techniques are available to detect changes in the property. For example, placement bands may be used to show the effects of technological and material changes, whereas experience bands are used to show the effects of business and operational changes. Such banding is necessary because the analyst does not have access to a database wherein each factor (e.g., change in materials/technology or operational environment) is held constant.

In order to help identify the effect of trends in the historical data, analysts in the telecommunications field often use "worm charts," so called for their resemblance to the shape of a worm. Figure 8-2, a worm chart, shows the indicated life obtained from each band.

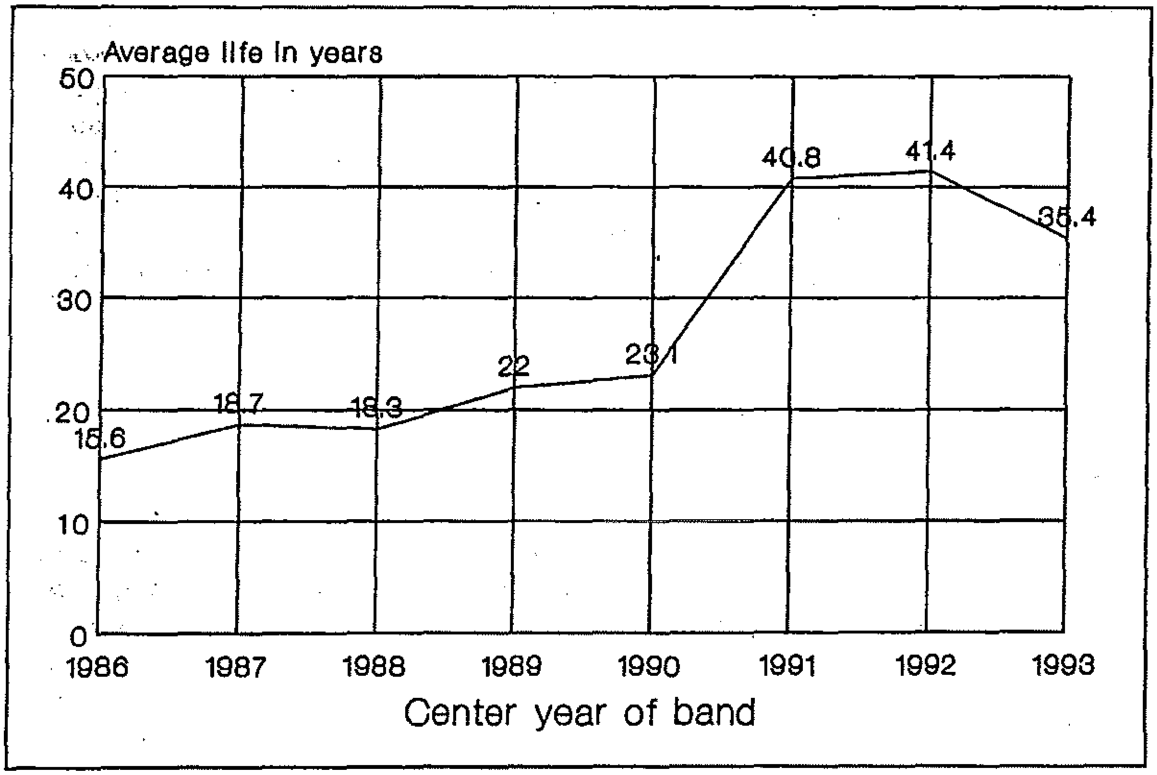

Figure 8-2. Worm Chart—Three-Year Band.

Selecting the Projection Life Curve

The projection life is a projection, or forecast, of the future of the property. Historical indications may be useful in estimating a projection life curve. Certainly the observations based on the property's history are a starting point. Trends in life or retirement dispersion can often be expected to continue. Likewise, unless there is some reason to expect otherwise, stability in life or retirement dispersion can be expected to continue, at least in the near term.

Depreciation analysts should avoid becoming ensnared in the mechanics of the historical life study and relying solely on mathematical solutions. The reason for making an historical life analysis is to develop a sufficient understanding of history in order to evaluate whether it is a reasonable predictor of the future. The importance of being aware of circumstances having direct bearing on the reason for making an historical life analysis cannot be understated. These circumstances, when factored into the analysis, determine the application and limitations of an historical life analysis.

Past Indications as a Measure of Future Activity

How well does an historical life analysis reflect what may happen in the future? Will history repeat itself? These questions must be answered in order to use the results of an historical life analysis. The analyst should become familiar with the physical plant under study and its operating environment, including talking with the field people who use the equipment being studied. For example, such discussions could reveal unique circumstances that brought about premature retirement of certain property. If these circumstances are not likely to happen again, the analyst should modify the study to reflect what would likely happen based on present operating conditions. For example, if the analyst discovers that corrosive material used in equipment was used in a certain past period and noncorrosive improved material which lasts much longer is predominantly used now, the analyst should discount the period in which corrosive material was used as not being representative of future activity. For further discussion, see Chapter II.

Other Factors to be Considered

Company Plans

In addition to talking with field people, the analyst should talk with management. Understanding past and present company policies concerning maintenance practices and retirements will determine how well historical retirement patterns will be repeated in the future. A company might retire automobiles every three years and trucks every five years. This pattern would be present in the historical data; however, if management changes its policy, this retirement pattern would also change. Management might also reveal planned future retirements that follow no historical pattern. In such a case, the analyst could modify the historical retirement pattern to reflect management's plans for retirement of certain facilities. If management has chosen a specific date for the retirement of certain facilities, then these facilities would comprise a life span group.

Technical and Economic Obsolescence

Technical and economic obsolescence are ongoing and an historical life analysis will reflect these factors to the extent that they were present in the past. Knowing the types of property susceptible to obsolescence will help determine the applicability of the historical retirement patterns to depict future plant life. For example, computer equipment is susceptible to technical obsolescence. Its historical, present, and future usage should be considered. When a utility has a continuing discernable pattern of updating its computer equipment, the historical life analysis will reflect technical obsolescence. However, when this pattern is broken, historical retirement patterns should be altered to reflect future use.

An example of economic obsolescence in the gas industry is products extraction equipment. This type of equipment is used to extract marketable byproducts sometimes present in natural gas production. The life of this equipment will partly depend on the market for the byproducts. With no available market this equipment will not follow the historical retirement pattern.

Regulatory and Customer Requirements

The effects of regulation and customer requirements, the costs of which may be hard to quantify, should also be considered. Regulatory requirements can cause both inadequacy and obsolescence, e.g., specifying that gas mains must be made from specific material or that telecommunications cables and electric distribution lines must be placed underground.

The two requirements can sometimes combine to cause change. An example of this may be a zoning conversion from an industrial to a residential area, which would result in changes in customer service requirements. The old electric power distribution system, e.g., lines, poles, and transformers, might be subject to premature retirement as the system is replaced with perhaps an underground residential distribution system. Public authorities can require plant to be relocated because of its interference with planned public uses, such as highway or other public transportation projects. Plant may also be replaced because its design fails to meet public standards of safety or appearance (aesthetics).

Most utilities use public rights-of-way. Consequently, municipalities or other owners of these rights-of-way may require the utility to move its facilities. Again, this usually results in premature retirement of utility plant. Therefore, if a utility is conducting a depreciation study, and there are known or anticipated public improvements involving loss of rights-of-way (for which the utility will not be reimbursed), consideration of this fact should be given by the analyst in developing service lives.

Obsolescence may cause retirements of plant items by rendering them uneconomical, inefficient, or otherwise unfit for service because of improvement in the art and technology, or because of changes in function. Retirements of this sort are especially relevant in the telecommunications industry, as competition forces change to more efficient and technologically superior equipment. For example, the replacement of copper cable with fiber optic cable not only enhances the operational efficiency but also provides the potential for future applications mandated by the changing requirements of customers and market forces.

Growth

Growth in demand for utility service may cause present facilities to become inadequate. The service life of longer life property may be shortened because of the need for capacity to carry a greater load. Growth in demand should be examined for the impact on past retirements and the analyst should consider whether future growth will alter the historical trend of retirements. If growth was present in the past and is expected to be slow in the future, then the analyst might expect service lives in the future to be greater than in the past. The historical period might be filled with replacements that were improvements over the property being retired. On the other hand, if future growth is expected to be greater than past growth, service lives may decrease because present property might not be adequate to handle future demand.

Informed Judgment

A depreciation study is commonly described as having three periods of analysis: the past, present, and future. The past and present can usually be analyzed with great accuracy using many currently available analytical tools. The future still must be predicted and must largely include some subjective analysis. *Informed judgment* is a term used to define the subjective portion of the depreciation study process. It is based on a combination of general experience, knowledge of the properties and a physical inspection, information gathered throughout the industry, and other factors which assist the analyst in making a knowledgeable estimate.

The use of informed judgment can be a major factor in forecasting. A logical process of examining and prioritizing the usefulness of information must be employed, since there are many sources of data that must be considered and weighed by importance. For example, the following forces of retirement need to be considered: Do the past and current service life dispersions represent the future? Will scrap prices rise or fall? What will be the impact of future technological obsolescence? Will the company be in existence in the future? The analyst must rank the factors and decide the relative weight to apply to each. The final estimate might not resemble any one of the specific factors; however, the result would be a decision based upon a combination of the components.

Judgment is not necessarily limited to forecasting and is used in situations where little current data are available. The analyst gathers what is known about a particular situation and modifies and refines the data to reflect the actual circumstances. The analyst's role in performing the study is to review the results and determine if they represent the mortality characteristics of the property. Using judgment, the analyst considers such things as personal experience, maintenance policies, past company studies, and other company owned equipment to determine if the stub curve represents this class of property.

The use of informed judgment sometimes becomes a point of controversy in the regulatory setting because some of the analyst's opinions cannot be quantified or easily supported. It is sometimes impossible to pinpoint the reasons for making a decision that diverges from a company's historical data or standard reference material. For instance, limited retirement data show that a new transformer design appears to have a significantly shorter service life; this would result in a significantly higher depreciation rate. Since this is a new design, there is no field experience to apply to the estimate, other than the scant data. Should the rate be based solely on the data? In the other extreme, should this preliminary data be given little weight and should the rate be based upon other types of transformers as reasonable indicators of the life of this new design? It is the analyst's responsibility to apply any additional known factors that would produce the best estimate of the service life. The analyst's judgment, comprised of a combination of experience and knowledge, will determine the most reasonable estimate.

In summary, several factors should be considered in estimating property life. Some of these factors are:

1. Observable trends reflected in historical data,
2. Potential changes in the type of property installed,
3. Changes in the physical environment,
4. Changes in management requirements,
5. Changes in government requirements, and
6. Obsolescence due to the introduction of new technologies.

CHAPTER IX

THE GENERATION ARRANGEMENT

Definition and Purpose

Under the straight-line method of depreciation accounting, the book investment, less its net salvage, is recovered over the average service life of the property. The average service life is estimated by blending past experience with forecasts of the future. The generation arrangement[1] is a process that accomplishes this blending.

In the generation arrangement, each generation represents a vintage of surviving property. The generation arrangement produces both the average service life and average remaining life. The average service life of the category is calculated from the vintage average lives.

There is a significant difference between the average life relating to a vintage group and the average service life relating to a category. The average life of a vintage group is an arithmetical average of the lives of its surviving and retired component units, whereas the average service life of the category is the reciprocal, or accrual weighted average, of the average lives of the component groups of a category. The average service life of a category changes according to the changing composition of its surviving groups.

The principal advantage of the generation arrangement is that it permits maximum utilization of actual experience. All available statistical data are used to calculate each vintage's average life and then are used to calculate the composite category average service life. Under the whole life technique, the average service life is used to calculate the whole life depreciation rate. In the remaining life technique, the vintage average life serves as a basis for weighting the vintage remaining lives which are used to calculate the category average remaining life. This composite average remaining life is then used to calculate the remaining life depreciation rate. Methods of weighting are discussed later in this chapter.

Therefore, the generation arrangement is used with both the whole life and remaining life techniques. The process can also be used with the ELG procedure (see Chapter XII). The generation arrangement allows some vintages in a category to be studied under the ELG procedures, and some vintages in the category may also be studied under other procedures using either the whole life or remaining life techniques.

Most property, with the exception of major equipment installations, consists of groups of many relatively small but easily identifiable items. These items are similar to one another, but the life of each item is not dependent upon the lives of the others. Furthermore, all items placed in service, in any one year seldom, if ever, retire simultaneously. Instead, the retirements are spread over many years according to a life table pattern. These are the mass property categories. The generation arrangement also provides a sound basis for calculating the average service life of major structure categories that are studied on a life span basis. This is

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[1] The generation arrangement is typically used only by the telephone industry. Therefore, the discussion in this chapter will be in reference to telephone plant equipment.

especially true where obsolescence has taken hold and no new major installations are being made but substantial investment is necessary to keep the plant in service.

Components

Table 9-1 illustrates the generation arrangement for a mass property category of plant. The plant is being studied, using historical data through December 31, 1995.

Table 9-2 shows for the 1990 vintage the Amount (investment) Surviving (Column B), the Proportion Surviving (Column F), and the Realized Life (Column G). Information such as that shown in Table 9-2 is required for each vintage included in the generation arrangement. Table 9-3 shows the calculation of the Average Remaining Life for each vintage (Column D).

The components of this generation arrangement are described and explained below. A definition is given for each column; the derivation of Columns B through E of Table 9-1 is shown in Tables 9-2 and 9-3. Descriptions of the columns in Table 9-1 are as follows:

Column A: Age of the surviving plant in service is as of January 1, 1996. It is assumed that plant is added evenly throughout the year; therefore, on the average at mid-year. For example, the age of the 1995 vintage is one-half year. The age of the 1990 vintage is 5.5 years.

Column B: Amount Surviving is the amount of investment surviving from the original vintage placement reduced by adjustments and retirements.

Column C: Proportion Surviving is the proportion of an original vintage placement that has survived retirement.

Column D: Realized Life is the life realized by the original addition in a vintage from the date placed to the study date.

Column E: Average Remaining Life is the average number of years remaining before retirement of each vintage. (See Table 9-3).

Column F: Average Life is a combination of the past and the future lives. The vintage average life is the sum of the Realized Life (Column D) and the Unrealized Life, which is the product of the Proportion Surviving (Column C) and the Remaining Life (Column E).

Column G: Average Life Weight is the Amount Surviving (Column B) divided by the Average Life (Column F).

Column H: Remaining Life Weight is the product of the Average Life Weight (Column G) and the Remaining Life (Column E).

TABLE 9-1

GENERATION ARRANGEMENT

Vintage	Age as of 1/1/96 A	Experience to 12-31-95			Remaining Life (Years) E	Average Life (Years) F=D+C*E	Average Life Weight G=B/F	Remaining Life Weight H=E*G
		Amount Surviving B	Proportion Surviving C	Realized Life D				
1995	0.5	398,962	.9974	0.50	11.55	12.02	33,192	383,362
1994	1.5	357,089	.9831	1.48	10.68	11.98	29,897	318,340
1993	2.5	350,607	.9609	2.45	9.86	11.92	29,413	290,016
1992	3.5	291,323	.9488	3.42	9.08	12.04	24,196	219,702
1991	4.5	288,689	.9217	4.34	8.34	12.03	23,997	200,139
1990	5.5	127,166[1]	.5877[2]	4.52[3]	7.64[4]	9.01	14,113	107,830
1989	6.5	237,510	.8995	6.30	6.98	12.58	18,880	131,782
1988	7.5	166,770	.8626	7.14	6.37	12.63	13,204	84,109
1987	8.5	114,267	.8312	7.97	5.79	12.78	8,941	51,768
1986	9.5	79,389	.7895	8.83	5.26	12.98	6,116	32,170
1985	10.5	64,080	.7227	9.45	4.76	12.89	4,971	23,662
1984	11.5	62,361	.7044	10.17	4.30	13.20	4,724	20,313
1983	12.5	44,466	.6279	10.45	3.87	12.88	3,452	13,359
1982	13.5	35,322	.5919	11.08	3.48	13.14	2,688	9,354
1981	14.5	34,756	.5893	12.29	3.12	14.13	2,460	7,675
1980	15.5	35,205	.5176	12.44	2.79	13.88	2,536	7,075
1979	16.5	47,210	.5112	13.51	2.50	14.79	3,192	7,980
1978	17.5	34,564	.4098	14.82	2.23	15.73	2,197	4,900
1977	18.5	29,676	.4470	15.88	1.98	16.77	1,770	3,505
1976	19.5	35,282	.3824	16.50	1.77	17.18	2,054	3,636
1975	20.5	27,505	.4241	17.57	1.57	18.24	1,508	2,368
1974	21.5	16,158	.3731	17.95	1.40	18.47	875	1,225
1973	22.5	14,437	.3556	18.46	1.24	18.90	764	947
1972	23.5	10,682	.2623	19.04	1.11	19.33	553	614
1971	24.5	13,194	.2281	20.77	.99	21.00	628	622
1970	25.5	11,710	.1783	20.98	.88	21.14	554	488
1969	26.5	6,660	.1274	21.62	.50	21.68	307	154
		2,935,040			8.1[5]	12.4[6]	237,902	1,927,095

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[1] *See Table 9-2, Column B for Activity Year 1996.*

[2] *See Table 9-2, Column F for Activity Year 1996.*

[3] *See Table 9-2, Column G for Activity Year 1996.*

[4] *See Table 9-3, Column D for Age 5.5.*

[5] *Composite Average Remaining Life = Total of Column H/Total of Column G.*

[6] *Composite Average Service Life = Total of Column B/Total of Column G.*

The development of Proportion Surviving (Column C) and Realized Life (Column D) is provided on Table 9-2 for the plant placed in 1990. One might expect the Proportion Surviving (Column C) of Table 9-1 to resemble the life table used to derive remaining lives, (Column B) of Table 9-3. This would assume that future retirements will follow the same pattern as past retirements, which is unlikely considering how erratic past retirements were. Note in Table 9-2, only 65.4% of the plant in service at the beginning of the third year survived to the end of that year. Of the plant in service at the beginning of the fourth year 96.3% survived to the end of that year. It is improbable that this performance will be repeated. The average remaining lives developed in Table 9-3 are derived from the projection life table (see Chapter VIII).

TABLE 9-2

VINTAGE YEAR 1990
DEVELOPMENT OF PROPORTION SURVIVING AND REALIZED LIFE

Activity Year A	Balance Beginning of Year B	Original Addition and Adjustments C	Retirements D	Survival Ratio E=(B-D)/B	Proportion Surviving Beginning of Year F(A)=E(A-1)*F(A-1)	Realized Life Beginning of Year $G(A)=\sum_{F(1)}^{F(A-1)} F(A) + 0.5*F(A)$
1990		230,225	414	.9982	1.000	
1991	229,811	(87)	666	.9971	.9982	0.50
1992	229,058	(2,063)	4,535	.9802	.9953	1.50
1993	222,460	(5,278)	77,038	.6537	.9756	2.48
1994	140,144	(942)	5,161	.9632	.6377	3.29
1995	134,041	(1,088)	5,787	.9568	.6142	3.91
1996	127,166				.5877	4.52

Column A: The calendar year in which additions, retirements, and adjustments occur from the 1990 vintage.

Column B: Amount surviving from original 1990 placement after adjustments and retirements. Note the value at activity year 1996. This figure (127,166) appears in the Generation Arrangement (Column B) at age 5.5.

Column C: The 1990 entry shows the <u>original addition</u>. Subsequent entries show transfer adjustments.

Column D: Amount retired each activity year.

Column E: Ratio of plant less retirements to plant balance.

Column F: The previous amount in Column E multiplied by the previous amount in Column F. The value at activity year 1996 (.5877) appears in the Generation Arrangement (Column C) at age 5.5.

Column G: The calculation for the 1990 vintage at 1996 involves summing the proportion surviving amounts from 1991 through 1995 plus one-half of the 1996 amount. The value at 1996, (4.52, rounded) appears in the Generation Arrangement (Column D) at age 5.5.

TABLE 9-3

PROJECTION LIFE TABLE/REMAINING LIFE DEVELOPMENT

Age A	Proportion in Service B[2]	Summation of Life Table $C = \sum_{B+1}^{END} B$	Average Remaining Life D=[C/B]+0.5
0.5	.99574	11.0041	11.55
1.5	.98391	10.0202	10.68
2.5	.96723	9.0530	9.86
3.5	.94520	8.1078	9.08
4.5	.91735	7.1904	8.34
5.5	.88328	6.3072	7.64
6.5	.84273	5.4644	6.98
7.5	.79557	4.6689	6.37
8.5	.74193	3.9269	5.79
9.5	.68220	3.2447	5.26
10.5	.61713	2.6276	4.76
11.5	.54785	2.0797	4.30
12.5	.47588	1.6039	3.87
13.5	.40310	1.2008	3.48
14.5	.33168	.8691	3.12
15.5	.26392	.6052	2.79
16.5	.20202	.4031	2.50
17.5	.14787	.2553	2.23
18.5	.10278	.1525	1.98
19.5	.06730	.0852	1.77
20.5	.04113	.0441	1.57
21.5	.02321	.0209	1.40
22.5	.01195	.0089	1.24
23.5	.00553	.0034	1.11
24.5	.00226	.0011	0.99
25.5	.00080	.0003	0.88
26.5	.00024	.0000	0.50
27.5	.00006	.0000	0.50
28.5	.00000	.0000	0.50
	11.99986		

Column A:	These are the same ages as shown in the Generation Arrangement.
Column B:	Life table values based on a 12-year Gompertz-Makeham curve. Alternatively, generalized curves, such as the Iowa curves, could be used.
Column C:	This value at each age is the sum of the life table values beyond that age. For example, the value at age 6.5 (5.4644) is found by adding the life table values from age 7.5 (.79557) through age 28.5 (.00001).
Column D:	The Remaining Life is the number of years remaining before retirement of each vintage. It is calculated by dividing the amount in Column C by the life table value in Column B and adding 0.5 years. For example, the average remaining life at age 8.5 equals (3.9269/.74193) + 0.5. The value at age 5.5 (7.64) appears in the Generation Arrangement (Column E) at age 5.5.

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[2] Based on following Gompertz-Makeham factors: c = 1.1550991; G = -.086446248; S = .0092192171; Projection Life = 12.00 years.

Methods of Weighting

General

When first exposed to the mechanics of depreciation studies, one surprising fact that most students are confronted with is that the average of 10 and 20 is not necessarily 15. Although yielding a mathematical average, a simple average of the lives of two different groups does not necessarily yield an appropriate average service life. And yet, a weighted composite life must be determined to serve as the depreciation period over which depreciation accruals are to be recorded.

Under the group plan, a number of units are combined to form a basic group, a number of these basic groups are then combined to form a broad group, and so forth until several super-groups or categories of plant are combined to form a class of plant or account. The average life of the units in the smallest group is determined by the arithmetic average of the individual lives or by direct weighting of the investment, whereas the average service life of combinations of groups or categories is determined by reciprocal (harmonic) weighting of the investment. The different methods of weighting are required since the average life of the units is applicable over its total life span, whereas the category average service life changes according to the changing composition of its component groups.

The basic group to which direct weighting applies varies with the depreciation method employed. Associated with the straight-line method are the vintage group and equal life group procedures. A vintage group consists of all the units placed in any one year. Within each vintage group all the units of equal life expectancy are grouped together to form an equal life group.

Direct Weighting

To explain the logic behind the two weighting methods (direct and reciprocal), consider a vintage consisting of two equal units with lives of 20 and 10 years. Through the use of direct weighting, the average life of the two units is determined to be 15 years. If the salvage is assumed to be zero, the depreciation rate is 6.67%. If these units are valued at $100 each, the accruals for each of the first ten years will be the investment of $200 multiplied by the 6.67% rate. By the end of the tenth year, two-thirds of the investment, or $133, will have been depreciated. For the next ten years, only one unit remains and the accrual each year is $100 multiplied by the 6.67% rate. By the end of the twentieth year, the $200 is completely depreciated.

Reciprocal Weighting

Consider the condition, however, where the two units are not members of the same basic group. For this example, assume that the unit with the 20-year life is placed first and the unit with the 10-year life is placed at the end of the first ten years so that both retire simultaneously. During the first ten years, accruals based on a rate of 5% (reciprocal of the 20-year life expectancy of this unit) total $50. If for the next ten years a direct weighted average life of 15 years is used, the accruals at a 6.67% rate per year for ten years total $133. The total depreciation at the end of the life of the two $100 units would be $50+$133 or $183 and the investment would not be fully depreciated.

Alternatively, for the last ten years of the units' lives, the reciprocal weighted average life of 13.3 years could be used. The reciprocal weighted average is calculated as follows:

Unit a	Gross Investment b	Average Life c	Weight d=b/c
A	$100	20	5
B	100	10	10
Total or Average	$200	13.3*	15

*total column b ÷ total column d

The depreciation rate and annual accruals are calculated as follows:

$$\text{Depreciation rate} = \frac{100\%}{13.3} = 7.5\%$$

$$\text{Annual Accruals} = \$200 \times 7.5\% = \$15$$

The accruals at 7.5% for ten years total $150 at the time of retirement of the two $100 units. The total amount depreciated is $50 + $150 or $200. Thus, the two units are fully depreciated.

Applying the ELG procedure to the above example, each of the units A and B would be members of separate life groups regardless of when they were placed. For the second condition wherein the 10-year life item was assumed to have been placed ten-years after the 20-year life item, the average life of the two units would be calculated using reciprocal weighting. For the first condition, wherein both units are placed at the same time, the average life for the first ten years would be the 13.3 years as determined by reciprocal weighting, inasmuch as we now have two different groups, and the average life for the last ten years would be the 20-year life of the remaining unit.

Compositing Lives of Several Categories

In computing the average service life of several categories of plant, reciprocal weighting is always used. For example, if the two units of the preceding example were considered as one category with an average service life of 13.3 years and combined with another category with investment of $300 and average service life of 5.0 years, the computation would be made as follows:

Category a	Gross Investment b	Average Service Life c	Weight d=b/c
A	$200	13.3	15
B	300	5.0	60
Total or Average	$500	6.7*	75

* total column b ÷ total column d

Weighting Methods for Remaining Life Studies

As is the case with average service life studies, weighting methods are used to develop composite lives for study categories or classes of property. In remaining life studies, a weighting method must also satisfy the requirement of an appropriate proration of the depreciation reserve. This proration is required when the reserve is not maintained by vintage, or study category, or plant account. A weighting method that satisfies these requirements is discussed below:

The book investment for each item (or category) divided by its average service life equals the weight to be multiplied by its remaining life. The composite remaining life then equals the sum of the products divided by the sum of the weights as shown below:

$$\text{Composite } RL = \frac{\sum \left(\dfrac{\text{Book Investment}}{ASL} \times RL\right)}{\sum \left(\dfrac{\text{Book Investment}}{ASL}\right)} \qquad (1)$$

When applied within a group with the same average life, the method is equivalent to direct weighting of the remaining lives.

When the actual reserve equals the theoretical reserve, the accruals developed from the composite remaining life will equal the sum of individually developed accruals. The method results in reasonable approximations of the composite remaining life even when discrepancies exist between the actual and theoretical reserves. However, it is important that actual reserves be maintained and used to the detailed degree practicable.

Salvage Weighting

The above discussion pertains to the weighting involved in compositing lives. The salvage was assumed to be zero. This is seldom the case and salvage needs to be considered in the compositing at some point. Before a depreciation rate can be determined, it is necessary to composite salvages of the several distinctly different categories with completely different salvage expectancies. It is sometimes desirable to determine an overall salvage component of a company-wide composite depreciation rate. There is a tendency to use direct weighting by multiplying the investment by the salvage for each category or class of plant and dividing their sum by the gross investment. This yields a correct average only when associated with an average life obtained by employing the gross investment less salvage in the compositing process.

Referring to the previous example, and assuming the salvage for Unit A is 10% while that for Unit B is 25%, the following two methods of compositing yield correct results:[3]

a. Average Service Life based on gross investment:

Unit a	Gross Investment b	Average Life c	Life Weight d=b/c	Net Salvage Percent e	Salvage Weight f=dxe
A	$100	20	5	10	50
B	100	10	10	25	250
Total or Average	$200	13.3[4]	15	20[5]	300

$$\text{Depreciation Rate} = \frac{100\%-20\%}{13.3 \text{ years}} = 6.0\%$$

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[3] "Units" A and B could just as well be "Categories" A and B, each consisting of many plant items.

[4] Average Service Life is the sum of column b divided by the sum of column d.

[5] Average Net Salvage is the sum of column f divided by the sum of column d.

b. Average Service Life based on gross investment less net salvage:

Unit a	Gross Investment b	Net Salvage Percent c	Salvage Amount d=bxc	Investment Less Salvage e=b-d	Average Life f	Life Weight g=e/f
A	$100	10	$10	90	20	4.5
B	100	25	25	75	10	7.5
Total or Avg.	$200	17.5[6]	$35	165	13.75[7]	12.0

$$\text{Depreciation Rate} = \frac{100\%-17.5\%}{13.75 \text{ years}} = 6.0\%$$

Both of these methods yield the same depreciation rate even though the life and salvage factors are different. Generally, it is permissible to use either method inasmuch as regulatory accounting rules usually require only that the depreciation rate be an appropriate composite without regard to life and salvage factors. The appropriateness of the 6% rate derived above is seen by comparing accruals for the A and B combinations (6% x $200=$12) with the sum of the accruals for the two individual categories which are 4.5% x $100 for category A and 7.5% x $100 for category B. The total is $12. The 4.5% and 7.5% depreciation rates are derived in Column g of part b above.

Whereas both methods yield the same depreciation rate, the method in part b can only be considered a mathematical exercise without significance for large numbers of units, which are found in group depreciation. If the plant consisted of only two units, unit depreciation would be employed rather than group depreciation. If the gross investment in Column b represents large quantities of units, then the actual average annual retirement amount over many years is likely to be $15 (the sum of life weights in Column d, part a) and the actual average annual salvage realized over many years will approximate 20% (the composite salvage in Column e of part a). The method discussed in part a is the most generally used.

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[6] Average Net Salvage is the sum of column d divided by the sum of column b.

[7] Average Service Life is the sum of column e divided by the sum of column g.

CHAPTER X

LIFE SPAN METHOD

General Principle

The life span method is the least complex method of computing service life of property for depreciation purposes and may be applied to individual units of property. A life span group contains units that will concurrently retire in a specific number of years after placement. For life span groups, there may be interim additions and retirements; however, all plant will be subject to a final retirement. Unlike mass property groups, life span groups often contain a small number of large units, such as an electric power generation unit or a telephone central office.

Life span and mass property have different retirement patterns and require different analysis. Mass property accounts use an age distribution, or generation arrangement, of survivors, produced by the actuarial or computed mortality methods. The life span accounts use primarily the unit investment surviving at a given date, e.g., December 31 of the study year. Life span property generally has the following characteristics:

1. Large individual units,
2. Forecasted overall life or estimated retirement date,
3. Units experience interim retirements, and
4. Future additions are integral part of initial installation.

Mass property categories have the following characteristics and are analyzed using full mortality and other methods as described in earlier chapters:

1. A large number of relatively small but homogenous units,
2. No definite overall life or planned final retirement date,
3. Units retire independent of each other, and
4. Additions are independent of existing units.

A life span group sometimes contains various categories of property which have the common event of final retirement at the same forecasted date. In the natural gas industry, exhaustion of supply is the event that can cause final retirement. The following classes of utility property may be most appropriately studied under this method, taking into consideration the availability of plant accounting data, and particularly the number of units of property involved: buildings, electric power plants, major high voltage substation and switching stations, telephone central office switching equipment, water filtration plants, dams and impoundments, and gas compressor stations. Another example is an offshore gas pipeline system that includes meters, valves, compressors, pipelines and other various equipment from which interim retirements occur until a final retirement when the offshore gas supply expires. Other classes of utility property such as aircraft or mainframe computers may also be candidates for the life span method.

Property studied using the life span method will usually have additions after the initial placement of the property and retirements prior to the final date of retirement of the property. Some interim additions may remain in service to the final retirement date, whereas others may be retired prior to this date. For example, a building may have a structural addition that will remain until the entire building is retired, whereas an addition such as a roof, plumbing, or internal partitions may be retired prior to the final building retirement. Appropriate estimates must be made for such interim retirements; however, interim additions are not considered in the depreciation base or rate until they occur.

A general characteristic of property studied using the life span method is the gradual increase in the depreciation rate as the property ages. Plant additions subsequent to the initial placement usually exceed the interim retirements, even though the additions may replace plant retired, because they are made at a higher cost than the plant retired. The result is a shorter average service life of the life span property. This shortening of the average service life demonstrates the importance of frequent review of classes of property studied using the life span method.

The definition of a final retirement using the life span method is the retirement of a major structural unit in its entirety. Interim retirements are minor components, and they may occur at any time during the life span of a unit. Interim retirements and additions include items such as changes within a building, or changes at an electric generating station, that do not alter the basic structure. For example, consider the case of a fossil-fired power plant. A final retirement would result if the structure or plant were completely wrecked or sold. However, the replacement of a cooling pump would result in an interim retirement.

Description of Methodology

Single Unit Without Interim Retirement

Figure 10-1 shows a survivor curve for a single electrical power plant that is retired (final retirement) after 30 years. This example contains no interim retirements. The average service life is the area under the curve.

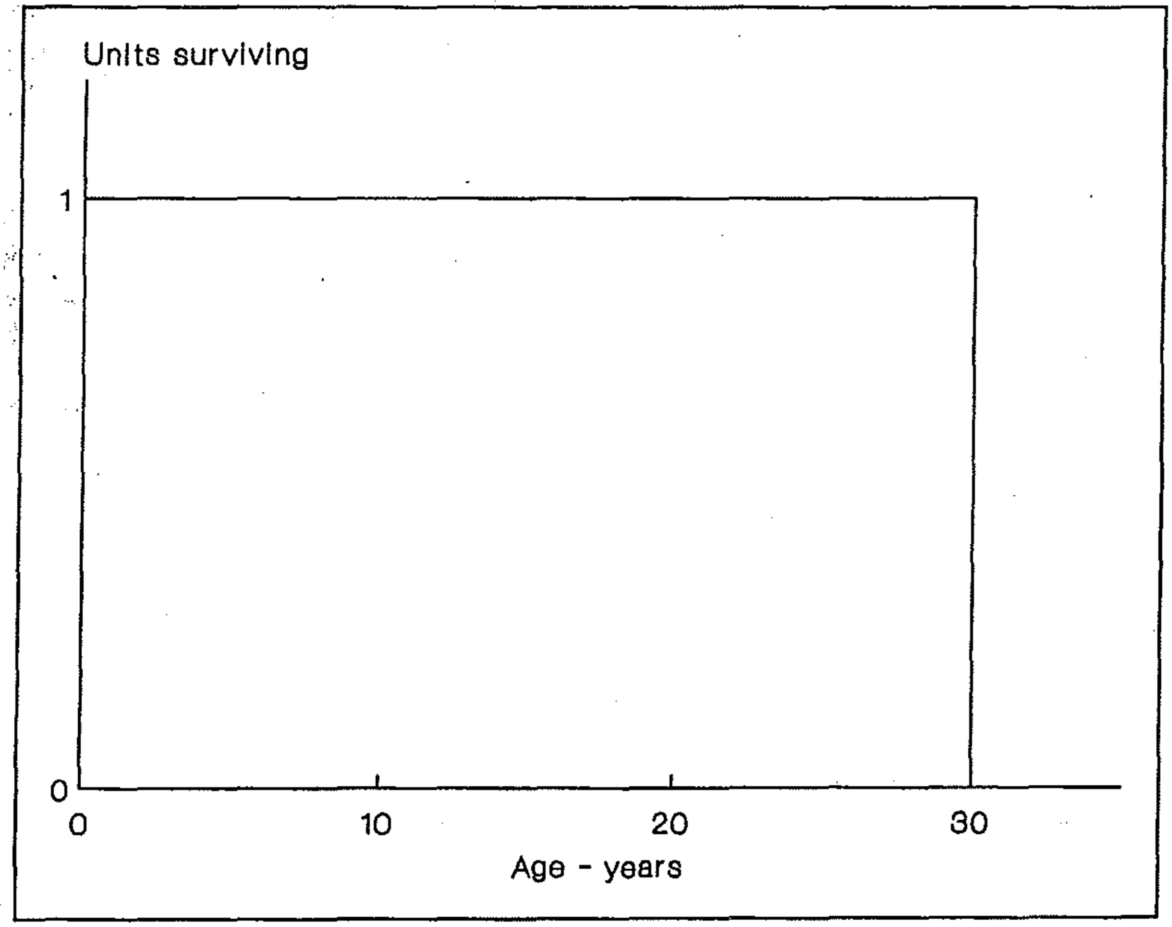

Figure 10-1. Single Unit Survivor Curve.

Single Unit with Interim Retirement

Figure 10-2 shows a survivor curve for a single electrical power plant retired after 30 years but with small interim retirements each year. In this example, the interim retirements are assumed to occur on a straight line. The average service life of 27 years is equal to the area ABCD. The interim retirements reduce the average service life by three years.

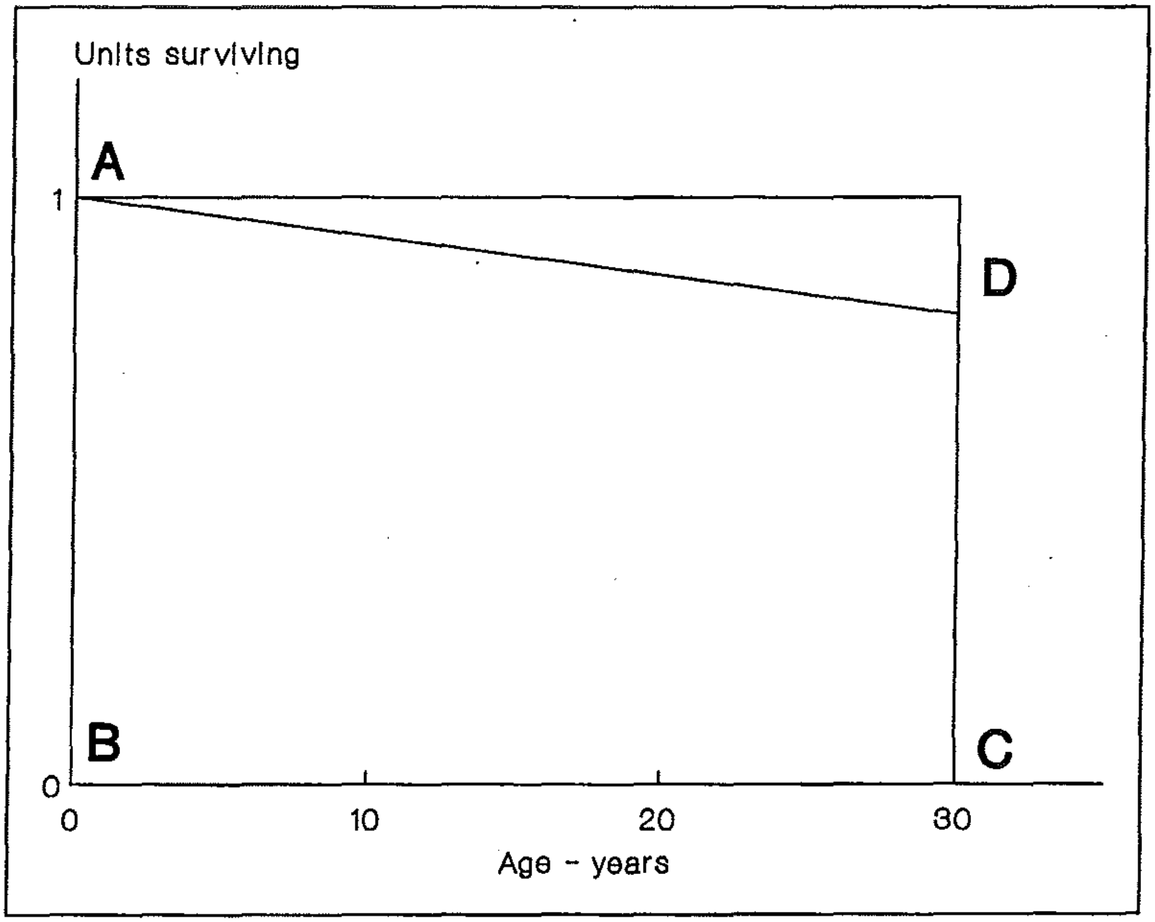

Figure 10-2. Life Span (Single Unit).

Multiple Units Without Interim Retirements

Figure 10-3 shows a survivor curve for three electrical power plants placed at the same time but with different final retirement dates (10, 20, and 30 years). If the three units have approximately the same original cost, the average service life of 20 years is the quotient of the area under the curve and the number of units (radix). If the units have different original costs, then the average service life is the quotient of the area under the curve (in dollars) divided by the total cost of the units.

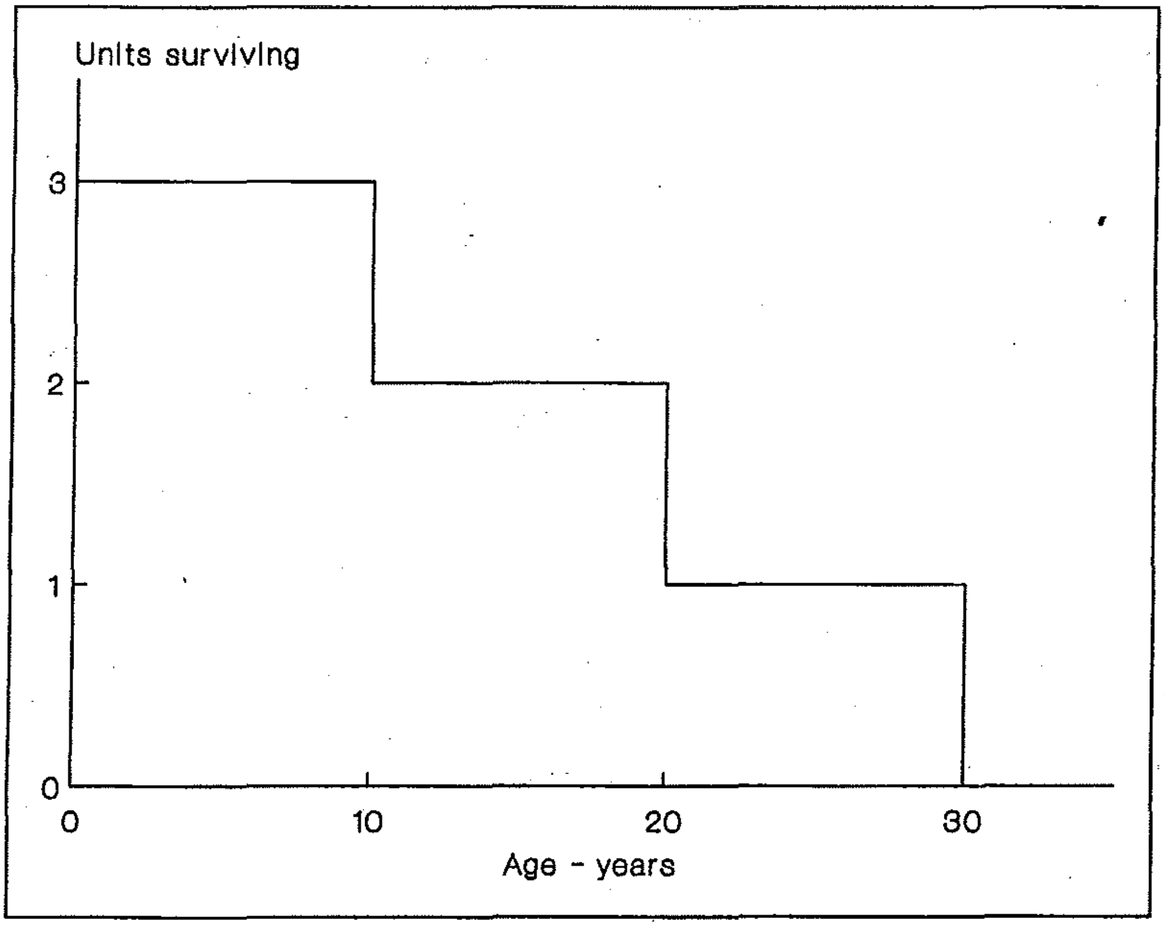

Figure 10-3. Three-Unit Survivor Curve.

Multiple (Group) Properties with Interim Retirements

The survivor curves discussed above show a single unit with and without interim retirements and three units without interim retirements. In each case, the final retirement date is considered in the development of the survivor curve. When developing the survivor curve for the life span group properties, however, final retirements are not included. If final retirements were included in the calculation of the interim life table, there would be large fluctuations in the observed data, making it difficult to graduate, or smooth, and extend the observed data.

The process used to determine interim life tables and to estimate average service lives and average remaining lives using the generation arrangement is discussed in later sections of this chapter.

Selecting Retirement Dates

As indicated in the above discussion, the final retirement date is the most important factor in the determination of a depreciation rate for life span properties. Therefore, an informed estimate of the final retirement date is essential to ensure adequate recognition of depreciation over the life of the property. Several factors are considered in selecting retirement dates, e.g., economic studies, retirement plans, forecasts, technological obsolescence, adequacy of capacity and competitive pressure.

Economic Studies and Retirement Plans

Retirement plans for utility properties are supported by various kinds of studies, including economic analyses. It is critical that vital information be considered; otherwise the study is analogous to a building which is structurally well built from the ground up but lacking a sound and proper foundation. Retirement decisions should be based on sound engineering and economic principles and practices so that management may be confident that the planned retirement of existing plant and approval of new investment are the most economical actions.

Forecasting

The first step in forecasting interim retirements, and the final retirement date, and thus the resulting service life, is to perform a statistical analysis of past experience. Statistical techniques used in life determinations are described in Chapters VII and VIII. The weight to be given past experience depends upon the extent to which conditions affecting service life in the future are expected to be similar to or different from those in the past.

The second step in forecasting is to consider the relevant forces of retirement such as wear and tear, decay, action of the elements, inadequacy, obsolescence, and public requirements.

Other factors such as an anticipated changeover to new or improved plant technology, or specific plans of management must be given consideration. These factors should be supported by proper economic analyses.

Average Year (or Date) of Final Retirement (AYFR)

AYFR is the direct weighted average of the individual estimated final retirement years for existing units in a major structure category. It is generally used in conjunction with an interim retirement life table to develop vintage group remaining lives. An example of the development of the AYFR is shown in Table 10-1.

TABLE 10-1

AVERAGE YEAR OF FINAL RETIREMENT (AYFR)

Retirement Period A	Estimated Retirements 1-1-94 ($000) B	Retirement Date C	Weighting D = B*(C-1900)
1994	10,364.6	1994	974,272.4
1995	11,788.2	1995	1,119,879.0
1996	12,786.9	1996	1,227,542.4
1997-1999	18,904.3	1998	1,852,621.4
2000-2002	33,378.6	2001	3,371,238.6
2003-2005	43,245.7	2004	4,497,552.8
TOTAL	130,468.3		13,043,106.6

Average Year of Final Retirement = 1900 + Total Column D/Total Column B = 2000.0

Allowing for Interim Retirements

Having calculated the AYFR, the remaining life from the study date is obtained by subtracting the study date from the AYFR. If no interim retirements were experienced before the date of final retirement, then the result is the average remaining life of the property in service. To calculate the average remaining life, the interim retirement life table is created using historical retirement rates.

Data Preparation

Interim retirement data needed to develop the interim retirement life table are not always readily available, but they may be developed by subtracting final retirements from total booked retirements. Table 10-2 shows the development of interim retirements and the computation of the interim retirement rate of 0.0075.

In order to calculate the average service life and average remaining life, it is necessary to have a distribution of the surviving investment, which should be available from the property records.

The Interim Retirement Curve

As shown in Figure 10-4, a survivor curve based on an interim retirement rate is linear or somewhat concave. The straight line curve assumes a constant retirement amount each year, whereas the Decreasing Exponential Curve assumes a constant retirement rate each year. An interim retirement curve is not expected to reach zero percent surviving because final retirements are excluded. The retirement ratios for each age are small, reflecting the fact that interim retirements are small when compared to the amount exposed to retirement.

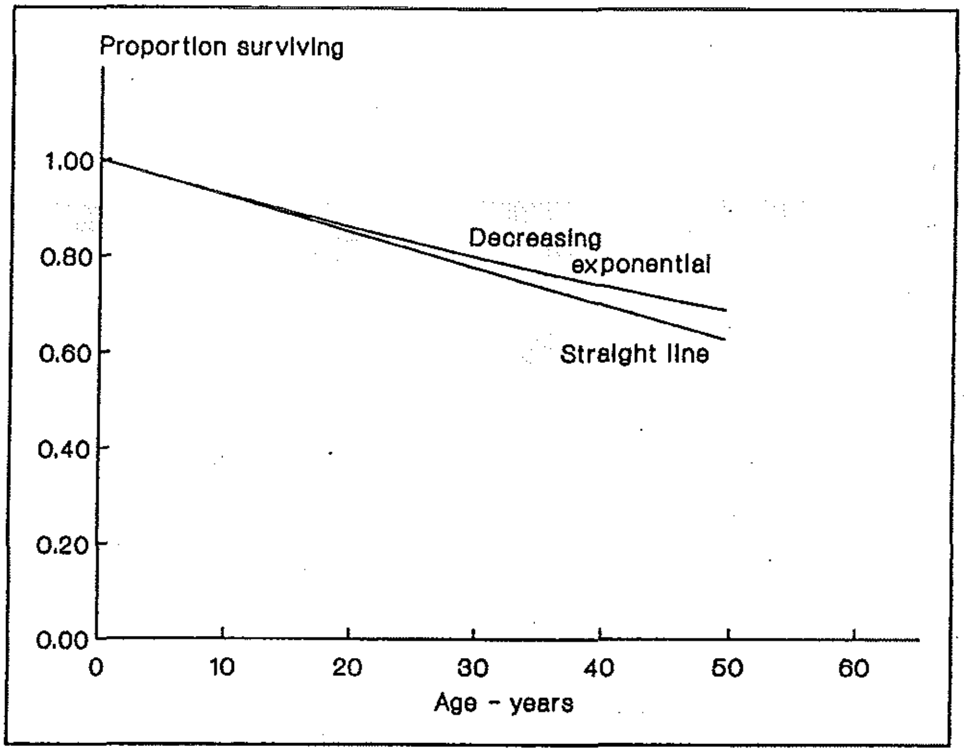

Figure 10-4. Interim Retirement Curves.

Two interim retirement life tables are developed in Table 10-3 and Table 10-4 using the 0.0075 annual retirement rate developed in Table 10-2. Table 10-3 is developed assuming a constant retirement amount each year, whereas Table 10-4 is based on a constant retirement rate each year. Figure 10-4 contains graphs of these two life tables.

TABLE 10-2

DEVELOPMENT OF AVERAGE INTERIM RETIREMENT RATE

Activity Year A	Average Plant Balance B	Total Retirements C	Final Retirements D	Interim Retirements E=C-D	Interim Retirement Rate F=E/H
1970	413,100	1,198	0	1,198	0.0029
1971	1,127,951	10,312	3,206	7,106	0.0063
1972	1,495,508	20,649	7,190	13,459	0.0090
1973	1,564,948	16,936	4,260	12,676	0.0081
1974	1,573,066	27,615	9,053	18,562	0.0118
1975	1,583,045	15,771	5,127	10,644	0.0067
1976	1,611,154	6,445	0	6,445	0.0040
1977	1,655,901	19,473	9,372	10,101	0.0061
1978	1,988,431	29,886	9,604	20,282	0.0102
1979	2,724,721	21,465	6,971	14,494	0.0053
1980	2,899,566	16,617	6,895	9,722	0.0034
1981	3,187,669	21,037	7,738	13,299	0.0042
1982	3,551,036	24,252	5,288	18,964	0.0053
1983	3,968,928	48,900	11,452	37,448	0.0094
1984	4,455,531	63,653	20,904	42,749	0.0096
1985	4,944,317	78,569	16,499	62,070	0.0126
1986	5,289,749	110,656	42,717	67,939	0.0128
1987	5,992,936	126,568	70,769	55,799	0.0093
1988	6,617,364	92,438	22,175	70,263	0.0106
1989	6,752,573	111,987	56,448	55,539	0.0082
1990	7,406,831	191,765	148,891	42,874	0.0058
1991	7,617,041	212,177	156,934	55,243	0.0073
1992	7,906,791	106,016	87,990	18,026	0.0023
1993	8,407,426	246,507	197,536	48,971	0.0058
1994	8,900,115	498,993	435,598	63,395	0.0071
TOTAL	103,635,698	2,119,885	1,342,617	777,268	

Average Interim Retirement Rate = Total Column E / Total Column B = 0.0075

TABLE 10-3

INTERIM RETIREMENT LIFE TABLE AS OF 1/1/94
Assuming A Constant Retirement Amount Each Year

Year Plant Placed A	Age End of 1993 B	Annual Retirement Rate C	Life Table D	2000 Retirement		2010 Retirement	
				Unrealized Life of Original Plant after 7/1/94 Note 1* E	Remaining Life of Surviving Plant after 1/1/94 (E/D)+0.5 F	Unrealized Life of Original Plant after 7/1/94 Note 1** G	Remaining Life of Surviving Plant after 1/1/94 (G/D)+9.5 H
1993	0.5	0.0075	0.99625	5.82000	6.34	14.92000	15.48
1992	1.5	0.0075	0.98875	5.77500	6.34	14.80000	15.47
1991	2.5	0.0075	0.98125	5.73000	6.34	14.68000	15.46
1990	3.5	0.0075	0.97375	5.68500	6.34	14.56000	15.45
1989	4.5	0.0075	0.96625	5.64000	6.34	14.44000	15.44
1988	5.5	0.0075	0.95875	5.59500	6.34	14.32000	15.44
1987	6.5	0.0075	0.95125	5.55000	6.33	14.20000	15.43
1986	7.5	0.0075	0.94375	5.50500	6.33	14.08000	15.42
1985	8.5	0.0075	0.93625	5.46000	6.33	13.96000	15.41
1984	9.5	0.0075	0.92875	5.41500	6.33	13.84000	15.40
1983	10.5	0.0075	0.92125	5.37000	6.33	13.72000	15.39
1982	11.5	0.0075	0.91375	5.32500	6.33	13.60000	15.38
1981	12.5	0.0075	0.90625	5.28000	6.33	13.48000	15.37
1980	13.5	0.0075	0.89875	5.23500	6.32	13.36000	15.37
1979	14.5	0.0075	0.89125	5.19000	6.32	13.24000	15.36
1978	15.5	0.0075	0.88375	5.14500	6.32	13.12000	15.35
1977	16.5	0.0075	0.87625	5.10000	6.32	13.00000	15.34
1976	17.5	0.0075	0.86875	5.05500	6.32	12.88000	15.33
1975	18.5	0.0075	0.86125	5.01000	6.32	12.76000	15.32
1974	19.5	0.0075	0.85375	4.96500	6.32	12.64000	15.31
1973	20.5	0.0075	0.84625	4.92000	6.31	12.52000	15.29
1972	21.5	0.0075	0.83875	4.87500	6.31	12.40000	15.28
1971	22.5	0.0075	0.83125	4.83000	6.31	12.28000	15.27
1970	23.5	0.0075	0.82375	4.78500	6.31	12.16000	15.26
1969	24.5	0.0075	0.81625	4.74000	6.31	12.04000	15.25

Derivation of Remaining Lives:

	Note 1*	Note 1**
Date of Retirement	7/1/2000	7/1/2010
Date of Study	1/1/94	1/1/94
Remaining Overall Life	6.5 Yrs	16.5 Yrs
To obtain Unrealized Lives after 7/1/94, Sum Column D from (B+1) to:	(B+6)	(B+16)

TABLE 10-4

INTERIM RETIREMENT LIFE TABLE AS OF 1/1/94
Assuming A Constant Retirement Rate Each Year

					2000 Retirement		2010 Retirement	
Year Plant Placed	Age End of 1993 A	Annual Retirement Rate B	Annual Survival Ratio C	Life Table D	Unrealized Life of Original Plant after 7/1/94 Note 1* E	Remaining Life of Surviving Plant after 1/1/94 (E/D)+0.5 F	Unrealized Life of Original Plant after 7/1/94 Note 1** G	Remaining Life of Surviving Plant after 1/1/94 (G/D)+9.5 H
1993	0.5	0.0075	0.9925	0.99625	5.82254	6.34	14.96095	15.52
1992	1.5	0.0075	0.9925	0.98878	5.77887	6.34	14.84874	15.52
1991	2.5	0.0075	0.9925	0.98136	5.73553	6.34	14.73738	15.52
1990	3.5	0.0075	0.9925	0.97400	5.69251	6.34	14.62685	15.52
1989	4.5	0.0075	0.9925	0.96670	5.64982	6.34	14.51715	15.52
1988	5.5	0.0075	0.9925	0.95945	5.60744	6.34	14.40827	15.52
1987	6.5	0.0075	0.9925	0.95225	5.56539	6.34	14.30021	15.52
1986	7.5	0.0075	0.9925	0.94511	5.52365	6.34	14.19295	15.52
1985	8.5	0.0075	0.9925	0.93802	5.48222	6.34	14.08651	15.52
1984	9.5	0.0075	0.9925	0.93099	5.44110	6.34	13.98086	15.52
1983	10.5	0.0075	0.9925	0.92400	5.40029	6.34	13.87600	15.52
1982	11.5	0.0075	0.9925	0.91707	5.35979	6.34	13.77193	15.52
1981	12.5	0.0075	0.9925	0.91020	5.31959	6.34	13.66864	15.52
1980	13.5	0.0075	0.9925	0.90337	5.27970	6.34	13.56613	15.52
1979	14.5	0.0075	0.9925	0.89659	5.24010	6.34	13.46438	15.52
1978	15.5	0.0075	0.9925	0.88987	5.20080	6.34	13.36340	15.52
1977	16.5	0.0075	0.9925	0.88319	5.16179	6.34	13.26317	15.52
1976	17.5	0.0075	0.9925	0.87656	5.12308	6.34	13.16370	15.52
1975	18.5	0.0075	0.9925	0.87000	5.08466	6.34	13.06497	15.52
1974	19.5	0.0075	0.9925	0.86347	5.04652	6.34	12.96698	15.52
1973	20.5	0.0075	0.9925	0.85700	5.00867	6.34	12.86973	15.52
1972	21.5	0.0075	0.9925	0.85057	4.97111	6.34	12.77321	15.52
19711	22.5	0.0075	0.9925	0.84419	4.93382	6.34	12.67441	15.52
1970	23.5	0.0075	0.9925	0.83786	4.89682	6.34	12.58233	15.52
1969	24.5	0.0075	0.9925	0.83157	4.86009	6.34	12.48796	15.52

Derivation of Remaining Lives:

	Note 1*	Note 1**
Date of Retirement	7/1/2000	7/1/2010
Date of Study	1/1/94	1/1/94
Remaining Overall Life	6.5 Yrs	16.5 Yrs
To obtain Unrealized Lives after 7/1/94, Sum Column D from (B+1) to:	(B+6)	(B+16)

Fitting with Type Curves

Curve fitting is the process of determining the trend or pattern developed from the known historical facts. Once data have been assembled, an observed interim retirement life table can be developed. This observed curve can be fitted to generalized life curves, e.g., Iowa curves or curves based on the Gompertz-Makeham formula. These curves and curve fitting processes are described in detail in Appendix A, parts 1-3.

The techniques used in curve fitting may be mathematical, graphical matching techniques with type curves, and/or visual inspection. Mathematical curve fitting is advantageous because the interim retirement curve may be based on broad experience bands.

The choice of the curve fitting technique could depend on the ease of handling the data and the ease of interpreting the results. The mathematical techniques may yield significantly better results, compared to graphical matching or the visual inspection process.

The Generation Arrangement

The generation arrangement is applicable even in cases where obsolescence is being experienced and no new installations are made but substantial sums of money are still being invested just to keep the plant. For life span categories the generation arrangement provides a sound basis for determining the average service life and average remaining life.

Vintage remaining lines are developed using an interim retirement rate and the AYFR to compute vintage average life expectancies. These remaining lives are combined with historical experience in the age distribution of the surviving investment, which is derived from actual or computed mortality experience, to develop the average service life.

Tables 10-5 and 10-6 are examples of interim retirement life and generation arrangement tables. The AYFR and survivor curve are based on the estimated retirement schedule in Table 10-1 and the interim retirement rate developed in Table 10-2.

TABLE 10-5

DEVELOPMENT OF VINTAGE GROUP REMAINING LIFE BY AGE

Constant Retirement Amount of 0.75% Each Year
Average Year of Final Retirement (AYFR) = 2000.0

Age Years A	Proportion Surviving at Age A B	Remain. Life of Surv. at Age A C*
0.5	0.99625	6.34
1.5	0.98875	6.34
2.5	0.98125	6.34
3.5	0.97375	6.34
4.5	0.96625	6.34
5.5	0.95857	6.34
6.5	0.95125	6.33
7.5	0.94375	6.33
8.5	0.93625	6.33
9.5	0.92875	6.33
10.5	0.92125	6.33
11.5	0.91375	6.33
12.5	0.90625	6.33
13.5	0.89875	6.32
14.5	0.89125	6.32
15.5	0.88375	6.32
16.5	0.87625	6.32
17.5	0.86875	6.32
18.5	0.86125	6.32
19.5	0.85375	6.32
20.5	0.84625	6.31
21.5	0.83875	6.31
22.5	0.83125	6.31
23.5	0.82375	6.31
24.5	0.81625	6.31
25.5	0.80875	6.31
26.5	0.80125	6.30
27.5	0.79375	6.30
28.5	0.78625	6.30
29.5	0.77875	6.30
30.5	0.77125	6.30
31.5	0.76375	6.29
32.5	0.75625	6.29
33.5	0.74875	6.29
34.5	0.74125	6.29
35.5	0.73375	6.28
36.5	0.72625	6.28
37.5	0.71875	6.28
38.5	0.71125	6.28
39.5	0.70375	6.27
40.5	0.69625	6.27
41.5	0.68875	6.27
42.5	0.68125	6.27
43.5	0.67375	6.26
44.5	0.66625	6.26
45.5	0.65875	6.26
46.5	0.65125	6.26
47.5	0.64375	6.25
48.5	0.63625	6.25
49.5	0.62875	6.25
50.5	0.62125	6.24
51.5	0.61375	6.24
52.5	0.60625	6.24
53.5	0.59875	6.23
54.5	0.59125	6.23
55.5	0.58375	6.23
56.5	0.57625	6.22
57.5	0.56875	6.22
58.5	0.56125	6.22
59.5	0.55375	6.21
60.5	0.54625	6.21
61.5	0.53875	6.20
62.5	0.53125	6.20
63.5	0.52375	6.20

* C = 0.5 + (Sum of Column B from Age A+1 thru Age A+W) / (Column B at Age A)
Where W = AYFR - Update Study Year = 2000 - 1994 = 6.0

TABLE 10-6

VINTAGE GROUP GENERATION ARRANGEMENT DEVELOPMENT OF AVERAGE SERVICE LIFE AND AVERAGE REMAINING LIFE

		Experience to 12-31-93						
Vintage N	Age as of 1/1/94 A	Amount Surviving $ B	Proportion Surviving C	Realized Life D	Average Remaining Life (Years) E	Average Life (Years) F=D+C*E	Average Life Weight $ G=B/F	Remaining Life Weight $ H=E*G
1993	0.5	1,828,667	0.7129	0.36	6.34	4.88	374,639	2,375,925
1992	1.5	2,922,264	0.5093	1.18	6.34	4.41	662,747	4,202,283
1991	2.5	7,717,653	0.4876	2.09	6.34	5.18	1,489,568	9,443,101
1990	3.5	7,965,902	0.4039	2.75	6.34	5.31	1,500,164	9,508,421
1989	4.5	5,368,639	0.3404	3.39	6.34	5.55	967,826	6,133,109
1988	5.5	5,258,767	0.2442	3.35	6.34	4.90	1,073,835	6,803,521
1987	6.5	3,683,447	0.2336	4.20	6.33	5.68	648,526	4,108,041
1986	7.5	4,598,126	0.2184	5.32	6.33	6.70	685,965	4,344,292
1985	8.5	6,191,377	0.2233	6.37	6.33	7.78	795,410	5,036,355
1984	9.5	3,387,032	0.2152	7.18	6.33	8.54	396,501	2,510,016
1983	10.5	3,914,741	0.2202	7.93	6.33	9.32	419,872	2,657,385
1982	11.5	2,737,503	0.1694	8.38	6.33	9.45	289,625	1,832,638
1981	12.5	4,243,715	0.2073	9.63	6.33	10.94	387,858	2,453,668
1980	13.5	3,846,535	0.1829	10.08	6.32	11.24	342,316	2,165,065
1979	14.5	2,722,972	0.2012	11.48	6.32	12.75	213,529	1,350,203
1978	15.5	2,509,267	0.2268	12.43	6.32	13.86	180,994	1,144,207
1977	16.5	2,369,870	0.2025	13.17	6.32	14.45	164,007	1,036,563
1976	17.5	2,178,383	0.1654	13.80	6.32	14.85	146,741	927,211
1975	18.5	1,859,716	0.1523	14.36	6.32	15.32	121,375	766,740
1974	19.5	2,265,620	0.1739	15.62	6.32	16.72	135,518	855,864
1973	20.5	1,649,409	0.1175	16.42	6.31	17.16	96,109	606,820
1972	21.5	1,927,770	0.1376	17.14	6.31	18.01	107,047	675,707
1971	22.5	1,625,585	0.1171	18.01	6.31	18.75	86,703	547,139
1970	23.5	2,323,368	0.1468	18.93	6.31	19.86	117,010	738,193
1969	24.5	2,063,953	0.1274	20.05	6.31	20.85	98,974	624,232
Prior		29,168,494	0.0406	26.60	6.29	26.86	1,099,505	6,917,025
Total		116,328,775					12,602,360	79,763,728

Average Service Life	Total B / Total G = 9.23071
Average Remaining Life	Total H / Total G = 6.32927
Total Computed Gross Additions	Sum of (B/C) = 1,104,543,297
Average Proportion Surviving	Total B / Sum of (B/C) = 0.10532