Customer Energy Efficiency Program
Measurement and Evaluation Program

FOURTH YEAR RETENTION STUDY FOR PACIFIC GAS & ELECTRIC COMPANY'S 1995 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAMS: LIGHTING AND HVAC TECHNOLOGIES

PG&E Study ID numbers:
324R1: Lighting
326R1: HVAC

March 1, 1999

Measurement and Evaluation
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FOURTH YEAR RETENTION STUDY FOR PG&E'S 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES PG&E STUDY ID #S: 324R1 & 326R1

Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission Decision 93-05-063, revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

This study measures the effective useful life (EUL) for all HVAC and lighting energy efficiency technologies for which rebates were paid in 1995 by Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Programs. Retrofits were performed under three different PG&E programs, the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customize Incentives (CI) Programs.

Methodology

The Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

For this study, the vast majority of measures were in place less than five years (few were installed prior to 1994, and follow-up data collection was conducted no later than the end of 1998). Because the ex ante EUL is 15-20 years for most measures, it is very unlikely that our data will be capable of accurately estimating the survival function for the studied measures.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data. For some measures, it was sufficient to only look at the raw data, because for some measures, all of the sampled equipment was still in place and operable. For measures that did exhibit some failures and removals, it was clear that such a small percentage of failures and removals had occurred, that it would be difficult to model the equipment's survival function.

2. ***Visually inspect*** the retention data, by simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time. This step clearly illustrated that for each studied measure, there was not enough data over time to support an accurate estimate of the survival function.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, a trend line was estimated using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we used the resulting trend line to estimate the EUL, which was statistically significantly larger than the ex ante estimate.

4. ***Develop a survival function*** using classical survival techniques. We modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we used the resulting survival function to estimate the EUL. In nearly every case, the resulting EUL was either statistically significantly larger than the ex ante EUL, or was not statistically significantly different than the ex ante EUL. In only 2 out of 15 cases was the resulting EUL statistically significantly less than the ex ante EUL. In both these cases the upper bound of the EUL was still within two years of the ex ante estimate.

Study Results

The exhibit below presents the final EULs for the studied and like measures. Provided are the ex ante and ex post EULs, the 80 percent confidence intervals for the ex post results, the final EUL used for the filing claim, and the realization rate.

PG&E's 1995 Commercial Energy Efficiency Incentives Program
Summary of Ex Post Effective Useful Life Estimates
Lighting and HVAC End Uses

1995 Measure Description	Code	EUL Ex Ante	EUL Ex Post	Upper 80% CL Ex Post	Lower 80% CL Ex Post	EUL for Claim -	Realization Rate -
LIGHTING							
T8 Lamps and Electronic Ballasts							
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXT	**L23**	**16**	**20**	**30**	**10**	**16**	**1.0**
FIXTURE: T-8, 1-LAMP, 4 FT FIXTURE	L9	16	-	-	-	16	1.0
FIXTURE: T-8, 2-LAMP, 4 FT FIXTURE	L10	16	-	-	-	16	1.0
FIXTURE: T-8, 3-LAMP, 4 FT FIXTURE	L11	16	-	-	-	16	1.0
FIXTURE: T-8, 4-LAMP, 8 FT FIXTURE	L12	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 2 FT FIXT	L21	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 3 FT FIXT	L22	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 8 FT FIXT	L24	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 1 31-W T-8 U OR 2 17-W T-8	L69	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 2 31-W T-8 U OR 4 17-W T-8	L70	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 3 31-W T-8 U OR 6 17-W T-8	L71	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 1 32-WATT T-8 LAMP	L72	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 2 32-WATT T-8 LAMPS	L73	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 3 32-WATT T-8 LAMPS	L74	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 2 8-FT T-8 OR 4 32-W, 4-FT T-8	L75	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 1 8-FT T-8 OR 2 32-W, 4-FT T-8	L160	16	-	-	-	16	1.0
Optical Reflectors w/ Fluorescent Delamp							
FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	**L19**	**16**	**-**	**-**	**-**	**16**	**1.0**
FIXTURE: MODIFICATION/LAMP REMOVAL, 2 FT LAMP REMOVED	L17	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 3 FT LAMP REMOVED	L18	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 8 FT LAMP REMOVED	L20	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40-W, T-10 W/ES BLST	L76	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40 W, T-10 W/ELEC BLST	L77	16	-	-	-	16	1.0
High Intensity Discharge							
HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	**L37**	**16**	**11**	**18**	**4**	**16**	**1.0**
HID FIXTURE: INTERIOR, STANDARD, 251-400 WATTS LAMP	**L81**	**16**	**11**	**18**	**4**	**16**	**1.0**
HID FIXTURE: INTERIOR, 0-100 WATTS LAMP	L25	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, STANDARD, 101-175 WATTS LAMP	L26	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, STANDARD, 176-250 WATTS LAMP	L27	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 0-35 WATTS LAMP	L78	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 36-70 WATTS LAMP	L79	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 71-100 WATTS LAMP	L80	16	-	-	-	16	1.0
HVAC							
Variable Speed Drive HVAC Fan							
ADJUSTABLE SPEED DRIVE: HVAC FAN, 50 HP MAX	**S22**	**16**	**18**	**34**	**3**	**16**	**1.0**
Water Chiller							
WATER CHILLER: >= 300 TONS, WATER-COOLED	**S11**	**20**	**-**	**-**	**-**	**20**	**1.0**
WATER CHILLER: < 150 TONS, WATER-COOLED	S9	20	-	-	-	20	1.0
WATER CHILLER: >= 150 & < 300 TONS, WATER-COOLED	S10	20	-	-	-	20	1.0
WATER CHILLER: < 150 TONS, AIR-COOLED W/CONDENSER	S12	20	-	-	-	20	1.0
WATER CHILLER: EARLY REPLACEMENT, > 150 TONS	S16	15	-	-	-	15	1.0
Cooling Tower							
COOLING TOWER	**S15**	**20**	**-**	**-**	**-**	**20**	**1.0**
Energy Management System							
INSTALL HVAC EMS	**204**	**14**	**-**	**-**	**-**	**14**	**1.0**

Regulatory Waivers

A regulatory waiver was filed for a company wide modification to the third and fourth earnings claim calculation methodology. This waiver was approved by CADMAC on February 17, 1999.

FOURTH YEAR RETENTION STUDY FOR PG&E'S 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES

PG&E Study ID#s: 324R1 & 326R1

FINAL REPORT

March 1, 1999

Submitted to

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1. EXECUTIVE SUMMARY

This section presents a summary of the retention study results of Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Program for lighting and HVAC technologies. The retention study described in this report covers all HVAC and Lighting technologies installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, REO, and CI programs and for which rebates were *paid* during calendar year 1995.

1.1 PROTOCOL REQUIREMENTS

This study was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols).[1] This evaluation has endeavored to meet all Protocol requirements.

The retention study results in ex post effective useful lives for each lighting and HVAC measure, and a comparison of realization rates from the ex ante to ex post estimates. The definition of the effective useful life, provided in Appendix A, Measurement Terms and Definitions, of the Protocols is: "an estimate of the median number of years that the measures installed under the program are still in place and operable".

Although there are dozens of measures installed under the Lighting and HVAC programs, the Protocols only require a subset of the measures be studied. The Protocols require the utilities to study either "the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by the net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less". For consistency, we will refer to the studied measures as the "Top 50% Measures" throughout this report. In addition to studying the Top 50% Measures, PG&E was also interested in studying one additional HID measure (Measure Code L37) and three additional HVAC measures: chillers, cooling towers, and EMS.

The Protocols state that "measures not included in the … retention studies will be divided into two groups: 'like measures' and 'other measures.' Like measures are defined by the Protocols as measures that are believed to be similar to measures included in the retention studies. We have classified all groups of like measures with similar applications, operating conditions, and operating loads.

Exhibit 1-1 presents the list of studied measures and associated like measures covered under this retention study. In addition, Exhibit 1-1 provides the percent of net resource benefit attributable to each studied measure. This complete list of studied and like measures has been submitted to and approved by the California DSM Measurement Advisory Committee (CADMAC).

[1] California Public Utilities Commission Decision 93-05-063, Revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

Exhibit 1-1
Mapping of Like Measures

Program and Technology Group	Studied Measures	Percent of Total Net Resource Benefit	Measure Grouping Like Measures
LIGHTING END USE			
Retrofit Express Program			
T8 Lamps and Electronic Ballasts	L23	26.7%	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
Optical Reflectors w/ Fluor. Delamp	L19	15.2%	L17, L18, L20, L76 - L77
High Intensity Discharge	L37,L81	7.2%	L25, L78 - L80, L26, L27
HVAC END USE			
Retrofit Express Program			
Adjustable Speed Drive HVAC Fan	S22	1.4%	N/A
Water Chiller	S11	0.0%	S9, S10, S12, S13, S16
Cooling Tower	S15	0.2%	N/A
Customized Incentives Program			
Energy Management System	204	6.0%	N/A

1.2 STUDY APPROACH OVERVIEW

As stated above, the Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

For this study, the vast majority of measures were in place less than five years (few were installed prior to 1994, and follow-up data collection was conducted no later than the end of 1998). Because the ex ante EUL is 15-20 years for most measures, it is very unlikely that our data will be capable of accurately estimating the survival function for the studied measures.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data. For some measures, it was sufficient to only look at the raw data, because for some measures, all of the sampled equipment was still in place and operable. For measures that did exhibit some failures and removals, it was clear that such a small percentage of failures and removals had occurred, that it would be difficult to model the equipment's survival function.

2. ***Visually inspect*** the retention data, by simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time. This step clearly illustrated that for each studied measure, there was not enough data over time to support an accurate estimate of the survival function.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, a trend line was estimated using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we used the resulting trend line to estimate the EUL, which was statistically significantly larger than the ex ante estimate.

4. ***Develop a survival function*** using classical survival techniques. We modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we used the resulting survival function to estimate the EUL. In nearly every case, the resulting EUL was either statistically significantly larger than the ex ante EUL, or was not statistically significantly different than the EUL. In only 2 out of 15 cases was the resulting EUL statistically significantly less than the ex ante EUL. In both these cases the upper bound of the EUL was still within two years of the ex ante estimate.

1.3 STUDY RESULTS

For the L19 Delamp, S11 Chiller, S15 Cooling Tower and 204 EMS measures, either no failures or only a few failures were observed in the collected data. Therefore, there was not a sufficient number of failures or removals to estimate an ex post EUL. Therefore, for these four measures the ex ante estimate remains, according to the rules in the Protocols.

For the four measures that had sufficient failures and removals, all four approaches discussed above were implemented. The results based on the summary statistics are not recommended, as they based solely on the overall failure/removal rate observed during the study period. In addition, the results based on the trendlines are not recommended, as they are based on a number of assumptions, as discussed earlier. Although neither of these two methods were recommended to be used as the final ex post result, they both provide useful results to validate the recommended method.

Therefore, the recommended results are based on the classical survival analysis using the LIFEREG procedure. Of the five distributions modeled, the gamma distribution is the most adaptive. The LIFEREG procedure models the generalized gamma distribution, which has three parameters. Because this model has at least one more parameter than any of the other distributions, it can take on a wide variety of shapes. In addition, the exponential, Weibull and log-normal distributions are all special cases of the generalized gamma model. But the generalized gamma model can also take on shapes that are unlike any of these special cases. Most importantly, it can have hazard functions with U or bathtub shapes, in which the failure rate (or hazard function) declines, reaches a minimum, and then increases.

Intuitively, then, one would expect the gamma results to provide a better model fit than either the exponential, Weibull or log-normal models (since these are all special cases of the gamma model). As expected, the gamma distribution generally provided the best model fit, as measured by the log-likelihood estimate provided by the LIFEREG procedure. Furthermore, the gamma model is the distribution that provided a result for each measure that was statistically significantly different than zero, measured at the 80% confidence interval[2]. For these reasons, we recommend that the survival function be based on the gamma distribution.

Exhibit 1-2 presents the recommended ex post estimates of the EUL. Because the gamma model did not provide results that were statistically significantly different from the ex ante results, measured at the 80 percent confidence interval, all of the ex post EULs are based on the ex ante estimates. The ex post estimates are compared to the favored study results, and the corresponding upper and lower 80 percent confidence interval, when available. Finally, the program realization rates are provided, which are the ratio of the ex ante and ex post estimates. For all measures, the realization rate is one.

Exhibit 1-2
Final Ex Post EUL Estimates

End Use	Technology	Measure	Ex Ante	Study Results Upper	Study Results Median	Study Results Lower	Ex Post	Realization Rate
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	16	-	-	-	16	100%
	T8 Lamps and Electronic Ballasts	L23	16	30	20	10	16	100%
	High Intensity Discharge	L37	16	18	11	4	16	100%
	High Intensity Discharge	L81	16	18	11	4	16	100%
HVAC	ASD	S22	16	34	18	3	16	100%
	Chiller	S11	20	-	-	-	20	100%
	Cooling Tower	S15	20	-	-	-	20	100%
	EMS	204	14	-	-	-	14	100%

Exhibit 1-3 presents the final EULs for the studied and like measures. Provided are the ex ante and ex post EULs, the 80 percent confidence intervals for the ex post results, the final EUL used for the filing claim, and the realization rate.

2 Please note that a result with a smaller standard error does not indicate that the model is a better fit. For example, a gamma distribution with a large standard deviation may be a much better fit than an exponential distribution with a small standard deviation. However, because the gamma distribution has a larger standard deviation, it will also have a larger standard error if the sample size is the same, since the standard error is equal to the sample standard deviation divided by the square root of the sample size.

Exhibit 1-3
Final EUL Estimates
For Studied and Like Measures

1995 Measure Description	Code	EUL Ex Ante	EUL Ex Post	Upper 80% CL Ex Post	Lower 80% CL Ex Post	EUL for Claim	Realization Rate
LIGHTING							
T8 Lamps and Electronic Ballasts							
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXT	**L23**	**16**	**20**	**30**	**10**	**16**	**1.0**
FIXTURE: T-8, 1-LAMP, 4 FT FIXTURE	L9	16	-	-	-	16	1.0
FIXTURE: T-8, 2-LAMP, 4 FT FIXTURE	L10	16	-	-	-	16	1.0
FIXTURE: T-8, 3-LAMP, 4 FT FIXTURE	L11	16	-	-	-	16	1.0
FIXTURE: T-8, 4-LAMP, 8 FT FIXTURE	L12	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 2 FT FIXT	L21	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 3 FT FIXT	L22	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 8 FT FIXT	L24	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 1 31-W T-8 U OR 2 17-W T-8	L69	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 2 31-W T-8 U OR 4 17-W T-8	L70	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 3 31-W T-8 U OR 6 17-W T-8	L71	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 1 32-WATT T-8 LAMP	L72	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 2 32-WATT T-8 LAMPS	L73	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 3 32-WATT T-8 LAMPS	L74	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 2 8-FT T-8 OR 4 32-W, 4-FT T-8	L75	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 1 8-FT T-8 OR 2 32-W, 4-FT T-8	L160	16	-	-	-	16	1.0
Optical Reflectors w/ Fluorescent Delamp							
FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	**L19**	**16**	**-**	**-**	**-**	**16**	**1.0**
FIXTURE: MODIFICATION/LAMP REMOVAL, 2 FT LAMP REMOVED	L17	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 3 FT LAMP REMOVED	L18	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 8 FT LAMP REMOVED	L20	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40-W, T-10 W/ES BLST	L76	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40 W, T-10 W/ELEC BLST	L77	16	-	-	-	16	1.0
High Intensity Discharge							
HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	**L37**	**16**	**11**	**18**	**4**	**16**	**1.0**
HID FIXTURE: INTERIOR, STANDARD, 251-400 WATTS LAMP	**L81**	**16**	**11**	**18**	**4**	**16**	**1.0**
HID FIXTURE: INTERIOR, 0-100 WATTS LAMP	L25	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, STANDARD, 101-175 WATTS LAMP	L26	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, STANDARD, 176-250 WATTS LAMP	L27	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 0-35 WATTS LAMP	L78	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 36-70 WATTS LAMP	L79	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, COMPACT, 71-100 WATTS LAMP	L80	16	-	-	-	16	1.0
HVAC							
Variable Speed Drive HVAC Fan							
ADJUSTABLE SPEED DRIVE: HVAC FAN, 50 HP MAX	**S22**	**16**	**18**	**34**	**3**	**16**	**1.0**
Water Chiller							
WATER CHILLER: >= 300 TONS, WATER-COOLED	**S11**	**20**	**-**	**-**	**-**	**20**	**1.0**
WATER CHILLER: < 150 TONS, WATER-COOLED	S9	20	-	-	-	20	1.0
WATER CHILLER: >= 150 & < 300 TONS, WATER-COOLED	S10	20	-	-	-	20	1.0
WATER CHILLER: < 150 TONS, AIR-COOLED W/CONDENSER	S12	20	-	-	-	20	1.0
WATER CHILLER: EARLY REPLACEMENT, > 150 TONS	S16	15	-	-	-	15	1.0
Cooling Tower							
COOLING TOWER	**S15**	**20**	**-**	**-**	**-**	**20**	**1.0**
Energy Management System							
INSTALL HVAC EMS	**204**	**14**	**-**	**-**	**-**	**14**	**1.0**

2. INTRODUCTION

This report summarizes the retention study of Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Program for lighting and HVAC technologies. The evaluation effort includes customers who were paid rebates in 1995. Technologies installed under the paid year 1995 CEEI Program were covered by three separate program options: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) Program and the Customized Incentives (CI) Program.

2.1 THE RETROFIT EXPRESS PROGRAM

The RE program offered fixed rebates to customers who installed specific electric energy-efficient equipment. The program covered the most common energy saving measures and spans lighting, air conditioning, refrigeration, motors, and food service. Customers were required to submit proof of purchase with these applications in order to receive rebates. The program was marketed to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

Lighting and HVAC end-use rebates were offered in the program for the following technologies:

Lighting Technologies

Halogen lamps

Compact fluorescent lamps

T-12 and T-8 fluorescent lamps

Compact fluorescent lamps and LED's

Electronic ballasts

T-8 and T-10 lamps and electronic ballasts

High-intensity discharge (HID) fixtures

Occupancy sensors, bypass or delay timers, photocells, and time clock controls

Removal of lamps and ballasts

HVAC Technologies

High-efficiency central air-conditioning units in various capacity ranges

Variable speed drive HVAC fans

High-efficiency package terminal air-conditioning units

Programmable thermostats, bypass timers, and electronic timeclocks

Reflective window film

Water chillers of various capacity ranges

Direct evaporative cooler units, evaporative condensers, and evaporative cooler towers

2.2 THE RETROFIT EFFICIENCY OPTIONS PROGRAM

The REO program targeted commercial, industrial, agricultural, and multi-family market segments most likely to benefit from these selected measures. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated amongst PG&E's divisions, emphasizing local planning areas with high marginal electric costs to maximize the program's benefits.

The REO program did not include any Lighting measures. Nine HVAC technologies, however, were included, which can be summarized into four general technology groups, described below:

Technology

Variable frequency drive supply fans

Installation of high efficiency water chillers

Variable air volume supply systems, which replace constant air volume supply systems

Evaporative cooling towers

2.3 THE CUSTOMIZED INCENTIVES PROGRAM

The Customized Incentives program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. These customers were required to submit calculations for projected first-year energy impacts with their applications prior to installation of the project. The maximum incentive amount for the Customized Incentives program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50 percent of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

Due to the significant documentation and analysis involved in Customized Incentives program measures, however, rebates for a number of 1992, 1993 and 1994 measures were delayed for payment until 1995. This evaluation covers those measures where rebates were paid in 1995

As a result of program design, the measures installed were similar to or the same as those for the RE program, but were installed in larger and more complex projects. The lighting measures are the same as those described above for the RE program. For HVAC, the following technologies were rebated in 1995:

Technology
HVAC variable speed drive
High efficiency chiller
Energy Management Systems (EMS)
Other miscellaneous Customized Incentives HVAC measures, which included: • Installation of various energy efficient motors • Installation of various HVAC controls • Various technologies (i.e., precoolers and economizers) added to increase overall system efficiency

2.4 STUDY REQUIREMENTS

The retention study described in this report covers all HVAC and Lighting technologies installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, REO, and CI programs and for which rebates were *paid* during calendar year 1995.

This study was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols).[1] This evaluation has endeavored to meet all Protocol requirements.

The retention study results in ex post effective useful lives for each lighting and HVAC measure, and a comparison of realization rates from the ex ante to ex post estimates. The definition of the effective useful life, provided in Appendix A, Measurement Terms and Definitions, of the Protocols is:

Effective Useful Life (EUL) – An estimate of the median number of years that the measures installed under the program are still in place and operable.

2.4.1 Studied Measures

Although there are dozens of measures installed under the Lighting and HVAC programs, the Protocols only require a subset of the measures be studied. The Protocols refer to the studied measures as the "Top 10 or Top 50% Measures", which is defined as:

Top 10 or Top 50% Measures – The utility should select the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by the net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less.

For the 1995 CEEI Program, the number of measures that constitutes the first 50% of the estimated resource value is only four. For consistency, we will refer to these measures throughout the report as the "Top 50% Measures."

For the 1995 CEEI Program, HVAC and Lighting comprise the studied end-uses. Among these end-uses, the following four measures shown in Exhibit 2-1 are identified as the "Top 50% Measures", as defined above.

Exhibit 2-1
Top 50% Measures for 1995 Paid Year

Paid Year	MDSS Measure Codes	Measure Description	% of Net Resource Benefit	Cummulative % of Net Resource Benefit
1995	L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	26.7%	27%
	L19	FIXTURE: MODIFICATION / LAMP REMOVAL, 4 FT LAMP REMOVED	15.2%	42%
	L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	7.2%	49%
	204	INSTALL HVAC EMS	6.0%	55%

[1] California Public Utilities Commission Decision 93-05-063, Revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

In addition to studying the measures identified in Exhibit 2-1, PG&E agreed to study on additional HID measure and three additional HVAC measures, shown in Exhibit 2-2. Adding these measures brings the cumulative net resource benefit studied up to 57 percent.

Exhibit 2-2
Additional Studied Measures for 1995 Paid Year

Paid Year	MDSS Measure Codes	Measure Description	% of Net Resource Benefit	Cummulative % of Net Resource Benefit
1995	S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	1.4%	56%
	S15	COOLING TOWER	0.2%	57%
	S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	0.0%	57%
	L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	0.0%	57%

This complete list of studied measures has been submitted to and approved by the CADMAC.

2.4.2 Like Measures

The Protocols state that "measures not included in the … retention studies will be divided into two groups: 'like measures' and 'other measures.' Like measures are defined by the Protocols as:

> **Like Measures** – measures that are believed to be similar to measures included in the retention studies.

We have classified all groups of like measures with similar applications, operating conditions, and operating loads. Exhibit 2-3 presents the mapping of studied measures to like measures. This measure mapping was submitted to the CADMAC for approval at the same time as PG&E's proposed Top 50% Measure list was submitted.

Exhibit 2-3
Mapping of Like Measures

Program and Technology Group	Measure Grouping: Studied Measures	Measure Grouping: Like Measures
LIGHTING END USE		
Retrofit Express Program		
T8 Lamps and Electronic Ballasts	L23	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
Optical Reflectors w/ Fluor. Delamp	L19	L17, L18, L20, L76 - L77
High Intensity Discharge	L37,L81	L25, L78 - L80, L26, L27
HVAC END USE		
Retrofit Express Program		
Adjustable Speed Drive HVAC Fan	S22	N/A
Water Chiller	S11	S9, S10, S12, S13, S16
Cooling Tower	S15	N/A
Customized Incentives Program		
Energy Management System	204	N/A

The Protocols require that "like measures adopt the same percent adjustment [or realization rate] for the measure effective useful lives of the similar studied measures . . . to adjust their ex ante measure effective useful lives."

Other measures are defined as:

Other Measures – measures that are different from the measures included in the retention study.

Therefore, other measures consist of all HVAC and Lighting measures that are not classified as either studied or like measures. The Protocols require that, for other measures, the ex ante estimate of the effective useful life will be adjusted by the average percentage adjustment [or realization rate] of all the studied measures within that end use."

2.4.3 Combining Program Years

The Protocols also require that two Program Years, 1994 and 1995, be combined and that the studies be conducted on the schedule for Program Year 1994. The Protocols state that combining the two studies "should increase the accuracy of the survival function and decrease the cost of completing the retention studies." Furthermore, "the retention studies shall include data from participant groups from two or more sequential years to increase the robustness of the sample and to allow for the estimation of a survival function for a number of different measures."

Because the Top 50% Measures for the 1995 Program Year are a subset of the 1994 Top 50% Measures, the Protocol's suggestion to combine the two studies will greatly enhance the accuracy of the retention study, without incurring additional cost.

2.4.4 Accepting Ex Post EULs

The Protocols state that "the estimated ex post measure EULs that result from the retention study will be compared to the ex ante EUL estimates. Hypothesis testing procedures will be used to determine if the estimated ex post measure EUL is statistically significantly different from the ex ante measure EUL. If the estimated ex post measure EUL is significantly different than the ex ante measure EUL, the estimated ex post measure EUL will be used. Otherwise, the ex ante estimate will continue to be used. Hypothesis testing will be conducted at the 20% significance level."

2.4.5 Objectives

The research objectives are therefore as follows:

- Collect data on the fraction of the measures that are in place and operable, for all studied measures.
- For each studied measure, calculate the ex post EUL, and the realization rates from ex ante to ex post.
- For each like measure, calculate the ex post EUL, based on a transferred realization rate from the studied measures.
- For each remaining HVAC and Lighting measure, calculate the ex post EUL, based on the average realization rate from all studied and like measures.
- Complete tables 6 and 7 of the Protocols.

2.5 STUDY APPROACH OVERVIEW

As stated above, the Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. At any given time, the hazard rate is the rate at which measures fail or are removed. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

Our overall approach was to apply survival analysis to our collected retention data in order to develop a survival function for each of the studied measures. Some of the common survival functions take on the logistic cumulative distribution function. Although there is no documentation to support the ex ante survival function assumptions, discussions with the authors of the Protocols indicated that the ex ante EULs are based on a logistic survival function.

However, the form of the logistic survival function assumed by the Protocol authors is *not* the commonly used form of the logistic model. Generally, in survival analysis, the log-logistic model is used, which is a special form of the logistic distribution. It is this distribution that we used in our analysis. Other commonly used survival functions are based on the exponential, Weibull, lognormal, and gamma distributions. For this retention study, we have examined each of these distributions. We have used the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System[2]," in order to estimate the survival functions based on the retention data for each of our studied measures.

An important issue to keep in mind for this analysis is the definition of survival. Recall that the EUL is defined as the median number of years that the measures installed under the program are still in place and operable. Therefore, to "survive", a measure must not have been removed or have failed. Unfortunately, it is likely that the underlying distribution of measures having failed is very different than the distribution of removals.

There is much literature to suggest, for example, that electronic ballast failures follow an exponential distribution. The exponential survival function has a constant hazard rate. In other words, the rate at which electronic ballasts fail is constant over time. This belief is founded on the fact that electronic devices are likely to fail at any point in time with equal probability. Because electronic ballasts may have anywhere from 30 to 120 parts, plus more than twice as many solder joints as there are parts, it is likely that the ballast may also fail at any point in time, with equal probability.[3]

However, the removal of an electronic ballast is more dependent on human interaction. For example, consider the act of remodeling, or upgrading the system as new technologies emerge. Both of these actions are likely to occur in the latter stage of the equipment's life. However, if the customer is not satisfied with the technology, the removal may occur early on in the equipment's life. Whatever the case may be, it is likely that the survival function of equipment removal differs from the survival function of the equipment failure.

For this study, the vast majority of measures were in place less than five years (few were installed prior to 1994, and follow-up data collection was conducted no later than the end of 1998). Because the ex ante EUL is 15-20 years for most measures, it was unlikely from the start that our data would be capable of accurately estimating this joint probability density function of failures and removals.

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[2] Allison, Paul D., "Survival Analysis Using the SAS System, A Practical Guide", SAS Institute, NC, 1995.

[3] Energy User News, Vol. 23 No. 10, October 1998. Electronics, Energy Products and Life-Cycle Costing, pp. 28.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data. For some measures, it was sufficient to only look at the raw data, because for some measures, all of the sampled equipment was still in place and operable.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerges.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

The details surrounding each of these steps are provided in Section 3.

2.6 REPORT LAYOUT

This report is divided into four sections, plus attachments. *Sections 1 and 2* are the *Executive Summary* and the *Introduction*. *Section 3* presents the *Methodology* of the evaluation. *Section 4* presents the detailed results and a discussion of important findings. *Attachment 1* provides summaries of the raw retention data by site and measure. *Attachment 2* includes retention sample design memos that have been drafted for the CADMAC Subcommittee on Persistence. Finally, *Attachment 3* provides the Protocol Tables 6B and 7B.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the Retention Study for the 1995 Pacific Gas & Electric Company (PG&E) Commercial Energy Efficiency Incentive (CEEI) Program. It begins with a detailed discussion on the sampling plan for the Retention Study. From there, details regarding the study methodology are presented, along with intermediate results from each of the four approaches implemented.

3.1 SAMPLE DESIGN

3.1.1 Existing Data Sources

PG&E's 1994 and 1995 first year CEEI program impact evaluations established "retention panels" of approximately 150 sites each for the Lighting and HVAC end uses. At each of these sites the rebated equipment was documented by make, model, and location. The total combined data collection effort resulted in a panel of over 300 Lighting, and over 250 HVAC sites.

Exhibit 3-1 provides the available sample frame for each studied measure. The studied measures comprise the five Top 50% Measures, in addition to three HVAC measures, which PG&E agreed to study. Nearly every site in the Lighting sample installed at least one of the studied measures. The HVAC sample, however, includes only 87 sites with at least one of the studied mesures. These retention panels were considered to comprise the available sample frame for this study.

Exhibit 3-1
Available Sample Frame by Studied Measure

MDSS Measure Code	Measure Description	Sample Frame
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	312
L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	94
204	INSTALL HVAC EMS	25
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	43
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	39
S15	COOLING TOWER	26
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	8
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	28

3.1.2 Sample Design Overview

As discussed in Section 2, the Protocols require that the Retention Study for the 1995 Paid Year Program combine the retention panel data collected for both the 1994 and 1995 Programs. Although the Protocols provide no requirement on sample size or expected relative accuracy for retention studies, they do require that the ex post estimates of EUL be statistically significantly different than the ex ante estimate, measured at the 80% confidence level, in order to accept the ex post estimate.

Therefore, the sample should be designed in such a manner that if the ex ante and ex post estimates were different, that the ex post estimate would be estimated accurately enough to reject the ex ante estimate at the 80% confidence level. This criteria alone is not sufficient to develop a sample. To do so, one would need to know the underlying distribution of the ex post estimate, and by how much the two means are expected to differ. Furthermore, the sample size that would be calculated would indicate the number of failures or removals needed to be observed, not the number of sites visited. Therefore, another component to this estimate would be the expected rate of failure / removals that would occur per site visited.

To complicate things even more, the unit of analysis for the retention study is not a site, but a unit of measure. For example, for lighting measures, the unit of analysis is generally a ballast. For chillers, the unit of analysis is tons. Therefore, a single site may consist of hundreds, or even thousands of units. In this case, each sample unit is not independent of the others. Therefore, the procedures for calculating required sample size is even more complicated.

This has been a major topic of interest for the CADMAC Persistence Subcommittee. Attachment 2 contains a few documents that discuss required sample sizes under certain conditions. The general consensus was that a sample of 30 or so site surveys should be sufficient.

We found that our sample frames were relatively limited for the majority of our measures, such that obtaining 30 completed follow-up surveys may not even be possible. For example, of our eight measures, only one had a sample frame greater than 100 sites. In fact, we could segment our measures by available sample frame into two categories: measures with a frame less than 100 sites, and measures with a frame greater than 300 sites. Our approach for developing a sample frame for these segments was based more on common sense than on statistics. For these two classes of measures, our sample approach was as follows:

- For measures with limited sample frames (defined as less than 100 sites) *conduct a census* with a goal of achieving *at least a 40% completion rate*. In our experience, we have generally been able to achieve this completion rate on longitudinal surveys.

- For measures with larger sample frames (greater than 300), obtain enough completes, such that *at least 30 sites have had some failure/removal* occur (e.g., at least one ballast failed or was removed).

We feel this sample design approach is much more robust than what could be obtained by making all the assumptions necessary to actually compute a required sample size. What we obtained, essentially, was *a census* for all measures except the L23 T8 measure, where we sampled *at least 30 sites that have had a failure or removal.*

3.1.3 Final Distribution

Exhibit 3-2 provides the final sample disposition. Shown are the number of sites available in the sample frame, the number of sites surveyed, and the number of surveyed sites that had at least one failure or removal. In addition, we have shown the number of units installed across all sites in both the sample frame and in the completed surveys.

As discussed above, a census was conducted on the L19 Delamp, L37 HID >=176W, L81 HID 251-400W, S11 Chiller, S15 Cooling Tower, S22 ASD and 204 EMS measures. Our goal of a 40 percent completion rate was achieved for each of these measures. In fact, over three-quarters of the available sample was surveyed for the L81 HID 251-400W, S11 Chiller, S15 Cooling Tower, and 204 EMS measures.

For the L23 T8 measure, our goal of surveying at least 30 sites that have had a failure or removal was also achieved. Although a census was not attempted (due to the large available sample frame) we surveyed more than 40 percent of the available sample.

Exhibit 3-2
Final Sample Disposition

Top 10 Measures	Measure Description	Retention Unis	Units in Retnetion Panel	Sites in Retention Panel	Sample Strategy	Units Contacted	Sites Contacted	Sites Contacted with Failures
L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	Ballast	21,503	312	30 completes w/ Failure	12,085	138	33
L19	FIXTURE: MODIFICATION / LAMP REMOVAL, 4 FT LAMP REMOVED	Lamp	7,153	94	Census	4,919	51	1
204	INSTALL HVAC EMS	System	24	24	Census	21	21	1
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	Fixture	1,201	44	Census	731	34	8
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	Fixture	576	29	Census	175	13	4
S15	COOLING TOWER	Ton	10,393	26	Census	10,022	24	0
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	Ton	5,284	8	Census	4,834	7	0
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	Ton	1,472	38	Census	548	16	2

3.1.4 Data Collection Strategy

The data collection effort surrounding the survival analysis included a combination of telephone and on-site surveys. When possible, these data were gathered using telephone surveys, with alternate data collection using on-site audits where installations were too complex to be supported by self-reported data. Roughly half of the survival analysis surveys were conducted over the telephone, with the other half requiring an on-site visit. In general, on-sites were required for many of the lighting end use installations, while HVAC equipment survival was more readily verified using the telephone interview only. The following outlines the data collection procedures:

A QC auditor contacted each site by telephone to assess whether an on-site audit was necessary, or if a telephone survey would suffice. If the QC auditor determined that the information could be obtained over the telephone, he conducted the telephone survey immediately, or at the customer's earliest convenience. If an on-site audit was deemed necessary, and the participant was willing, the auditor scheduled an appointment and visited the site.

Equipment survival data were collected by the QC auditor, who prompted each site contact to locate the retention technologies using information available from the retention panels. At that time, information was recorded regarding the success or failure in locating the panel-specified equipment.

For each unit of equipment in the retention panel, it was determined whether (1) the equipment was still installed, and (2) if it was operable. If the equipment was not in place or was not operable, it was determined when it was removed or stopped operating according to the owner or operators best recollection. Reasons for removal or failure to operate were also collected. If equipment as replaced, it was determined if the equipment was replaced with a standard, equivalent or higher efficiency technology. Finally, it was determined if replaced equipment was done so under warranty.

3.2 ANALYSIS OVERVIEW

As discussed in Section 2.4, the purpose of a retention study is to collect data on the fraction of measures place and operable in order to produce a revised estimate of its EUL. The desired result of our approach was to apply survival analysis to our collected retention data in order to develop a survival function for each of the studied measures. However, because our retention data only includes information over the first few years of the measures' lives (which are expected to have median lives of 15-20 years), we were concerned that our data would not support an accurate estimation of a survival function.

Our concern is supported by Exhibit 3-2 above, which presents the number of sampled sites that had at least one measure unit that failed or was removed. Of the eight measures studied, two of them had no sites surveyed with a single failure or removal. In addition, two other measures had only one or two failures. Therefore, it will be impossible to develop a survival function for some of the measures studied.

Before attempting to estimate a survival function for a given measure, we first evaluated the data collected to see if there was enough data to support an estimate. For this step, for each studied measure, we compiled summary statistics on the raw retention data, and visually inspected the empirical survival function that we observed over the first three to four years.

Next we used the empirical survival function to forecast the survival function using basic linear regression techniques. We analyzed both a linear trend, as well as an exponential trend (which is one of the most common forms of a survival function.) Of course, this step was only performed for studied measures that had exhibited some failures or removals in the sample.

Finally, we used classical survival analysis techniques to develop a survival function. This analysis was performed using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System." As part of this step, we attempted to model the survival function using five of the most commonly used survival distributions: exponential, logistic, lognormal, Weibull and gamma. Again, this step was only performed for the studied measures that had exhibited some failures or removals in the sample.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data.
2. ***Visually inspect*** the retention data.
3. ***Develop a trend line*** from the survival plots.
4. ***Develop a survival function*** using classical survival techniques.

The details surrounding each of these methods is provided below.

3.3 SUMMARY STATISTICS

As discussed above, the first step of our analysis was to compile summary statistics on the sample retention data. For each measure in our sample, these statistics include:

- the number of units installed at the site (as documented in the original retention panel);
- the number of units still operable and in place;
- the number of units that had failed, been removed and been replaced;
- the number of failed units that had been replaced under warranty;
- the percentage of units that had failed, been removed or been replaced; and
- the ex ante EUL.

The CADMAC has agreed that failed equipment that is replaced under warranty should be counted as if it is still operable and in place.

Exhibit 3-3 summarizes this data at the measure level. Attachment 1 provides this data for each site sampled, by studied measure.

Exhibit 3-3
Summary Statistics on Retention Sample Data

End Use	Technology	Measure	Number of Sites Contacted	Units	Total Number of Units	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	51	Lamps	4,883	2	0	4,881	0.04%
	T8 Lamps and Electronic Ballasts	L23	138	Ballasts	12,085	361	110	11,834	2.08%
	High Intensity Discharge	L37	13	Fixtures	175	17	1	159	9.14%
		L81	34	Fixtures	771	35	0	736	4.54%
HVAC	ASD	S22	16	hp	548	15	0	533	2.74%
	Chiller	S11	7	Tons	4,834	0	0	4,834	0.00%
	Cooling Tower	S15	24	Tons	10,022	0	0	10,022	0.00%
	EMS	204	21	systems	21	1	0	20	4.76%

Exhibit 3-3 clearly demonstrates that for the S11 Chiller and S15 Cooling Tower measures, it will be impossible to develop a survival function or an ex post EUL estimate. Both of these measures exhibited no failures or removals in the sample. Furthermore, the L19 Delamp and 204 EMS measures exhibited only one or two failures or removals in the sample. With such limited data on failures, a reliable survival function cannot be developed nor can an ex post EUL estimate. Because of this, no further analysis was conducted on the S11 Chiller, S15 Cooling Tower, 204 EMS or L19 Delamp measures. The ex ante estimate was assumed for the ex post estimate of the EUL for these four measures.

Even though the 204EMS measure did exhibit a 4.76 percent failure/removal rate, this is based on a sample of only one failure/removal in 21. Even if we were to assume a constant rate of one failure/removal per 21 installations every three years (a conservative estimate of the number of years of data collection), we would still obtain an ex post estimate that greatly exceed the ex ante, which is usually 14 years for 204 EMS meaures.

For the other four measures (L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD), we had enough data on failures to proceed to the next analysis step. However, examination of the data presented in Exhibit 3-3 indicates that we will likely obtain ex post estimates of the EUL that greatly exceed the ex ante.

If we make the assumption that the failure/removal rates provided in Exhibit 3-3 are constant over time, then our survival function would take on the exponential distribution, which is one of the most commonly used distributions in survival analysis. Assuming the failures/removals occurred over a three year period (which is conservative), we can estimate the median EUL. Exhibit 3-4 provides the estimated EULs based on these assumptions.

Exhibit 3-4
Illustrative Ex Post EUL Estimates
Based on Exponential Distribution and Conservative Assumptions

End Use	Technology	Measure	Percent Failed, Removed, Replaced	Annualized Failure, Removal, Replacement Rate^	Median Life*	Ex Ante EUL
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	0.04%	0.01%	5,077	16
	T8 Lamps and Electronic Ballasts	L23	2.08%	0.69%	100	16
	High Intensity Discharge	L37	9.14%	3.05%	23	16
		L81	4.54%	1.51%	46	16
HVAC	ASD	S22	2.74%	0.91%	76	16
	Chiller	S11	0.00%	0.00%	-	20
	Cooling Tower	S15	0.00%	0.00%	-	20
	EMS	204	4.76%	1.59%	44	14

^ Assuming a percentage of failed, removed, replaced occurs over three years.
* Assuming a constant failure rate over time.

Even based on these conservative assumptions, the estimates of median lives greatly exceed the ex ante estimates of EUL.

Attachment 1 provides the site-specific data used to develop the summary presented in Exhibit 3-3. It is important to note that during some of the follow-up surveys (which were done either on-site or over the phone by an experienced engineer), it was not always possible to identify the exact equipment that was included in the retention panel. In some cases we were unable to identify the exact amount of equipment at the facility, which sometimes lead to larger or smaller estimates of equipment in place and in operation.

Because we obtained counts of the number of units that had failed, been removed or been replaced, we could verify the unit counts in the retention panel. This was done by adding the number of units found to be in place and operable, to the number of units that had failed, been removed or been replaced. In the cases where the number of verified units was smaller than the number of units in the retention panel, we conducted our analysis on only the number that we verified during the survey.

In the cases where the number of units found to be in place and operable was greater than the amount in the retention panel, it was assumed that all of the units in the retention panel were in place and operable.

3.3 VISUAL INSPECTION

For this step, we developed an empirical survival function that was observed from the raw retention data over the first three to four years of the measures' lives. As discussed above, this task was only conducted for the L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD measures, which exhibited a sufficient amount of failures or removals in the sample data.

To develop the empirical function, we calculated for each month the percentage of equipment that was in place and operable. Although this appears to be a straightforward calculation, there were two issues that arose:

- The dates associated with failures and removals were not always well populated.
- Not all customers were surveyed over the same length of time.

Missing Failure Dates

Two common terms used in classical survival analysis are "left-hand censoring" and "right-hand censoring". Left-hand censoring means that it is known that a failure/removal has occurred, but it is unknown when the failure/removal occurred. It is only known that the failure/removal occurred before a certain date.

Right-hand censoring is more common in our data. Right-hand censoring means that at the last time the customer was surveyed, a failure/removal had not occurred, so the time when the equipment will fail or be removed is unknown.

The SAS procedures that are discussed below in Section 3.5 are capable of handling right-hand censored data, and in some cases left-hand censored data. But for this more simplistic task, some assuptions are required.

In order to develop our empirical distribution, we needed to have an estimate of each failure date. We considered four different approaches to estimating the failure dates:

1. Choose the earliest possible date, which would be the date the retention panel was developed. This was usually one year after the installation.
2. Choose the latest possible date, which would be the date the follow-up survey was completed. This could be anywhere from 2 to 5 years after the installation date.
3. Choose the mid point between the two dates above.
4. Generate a random date between the two dates above, based on a uniform distribution.

It is important to note that approximately 20 percent of the failure dates were missing.

Below in Exhibit 3-7, we present the survival functions based on each of these methods, for the L23 T8 measure. We still needed to resolve the issue of survey length.

Survey Length

The topic of right-hand censoring is directly related to the issue of customer survey length. The issue of having customers surveyed at the same time is not much of a concern. Because our empirical survival function looks only at the percentage of equipment that has failed in each month *since installation*, it is not necessary to have each customer's installation date occur at the same time.

What is more problematic is that some customer follow-up surveys were conducted 36 months after their installation, and others had follow-up surveys conducted 48 months after their installation. Therefore, when we calculate the percentage of equipment in place and operating for, say, month 37 there will be some customers who were last surveyed 36 months (or less) after their installation date. For these customers, if a failure/removal occurred prior to month 37, then we know the unit is not operable and in place during month 37. However, if the equipment did not fail or become removed prior to month 37, we cannot say for certain if the equipment is still in place and operable in month 37. This leaves us with three alternatives for developing our empirical distribution. When we are calculating the percent of equipment operable and in place for month M, but the equipment was last surveyed prior to month M, we can:

1. Not include the equipment at all, regardless if a failure/removal occurred prior to month M.

2. Only include the equipment if a failure/removal occurred prior to month M, because we know that the equipment is still failed or removed in month M.

3. Include the equipment regardless of failure/removal, and assume the equipment is still operable if it has not failed or been removed prior to month M.

Clearly, the third option overstates the percent of equipment that is in place and operable. Also, the second option is likely to understate the percent of equipment that is in place and operable, because you are not counting equipment that was operating up to month M, which is still likely to be operating in month M. Finally, the first option is probably the only unbiased estimate, but has the potential to result in a survival function that violates its non-increasing property. In other words, because the sample size changes for each month, it is possible that in one month the percent operable and in place could exceed the following months percentage (which violates the non-increasing property of a survival function.)

Even with the potential problems suggested with the first option, we feel this is the most accurate method. What we suggest is to only look at the first 30 to 40 months of data, when the majority of the population is still providing usable data, and the survival function is still nonincreasing. To be conservative, we also developed empirical functions based on the second option. We did not develop functions based on option three because we felt this to be the most biased of the alternatives, especially in later months. Below, we explore the sensitivity of all of the options discussed above, for both survey length and missing failure dates.

Solutions

Exhibits 3-5 through 3-8 were developed in an attempt to address each of these various issues discussed above. First, Exhibit 3-5 provides the percentage of customers that had a survey length (defined as number of months the follow-up survey was conducted after installation) greater or equal to a given number of months. This illustrates the percentage of the customers that would contribute to the calculated percentage of operating equipment in option one above. Exhibit 3-5 shows that half of the sample had a survey length of at least 40 months.

Exhibit 3-5
Percentage of Equipment with Survey Length
Greater than or Equal to a Given Month

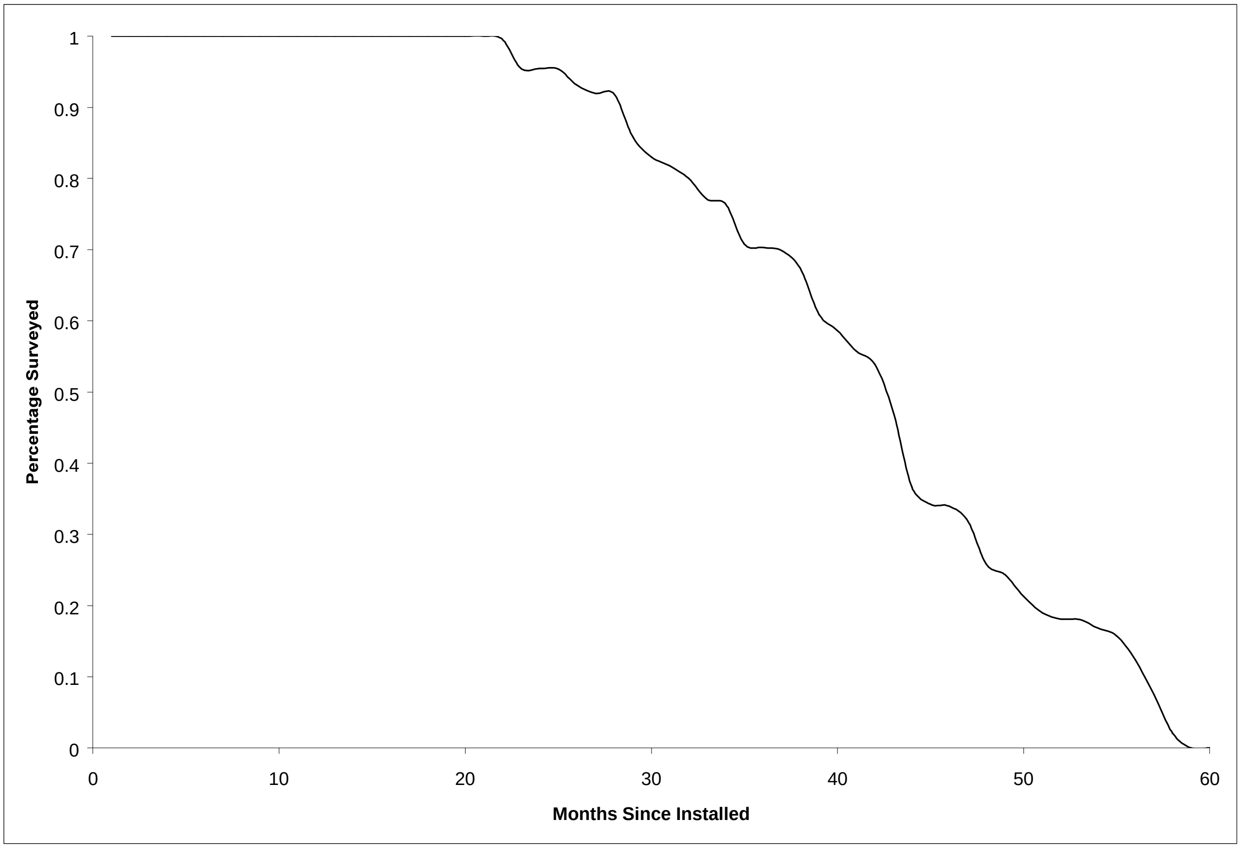


Exhibit 3-6 plots the empirical survival function for the L23 T8 measure under the following assumptions: for missing failure dates, use a random date; also, do not include the equipment if the survey date occurred prior to month M. The purpose of this exhibit is to illustrate how the survival function can become volatile as the sample frame decreases. As stated above, only half of the sample would contribute to the estimate of the survival function in month 40. After this point, we see that the survival function is no longer non-increasing, and has some rather large spikes. For this reason, we have decided to only use the first 40 months to plot the survival function for the L23 T8 measure.

Exhibit 3-6
Empirical Survival Function for L23 T8 Measure
All Months

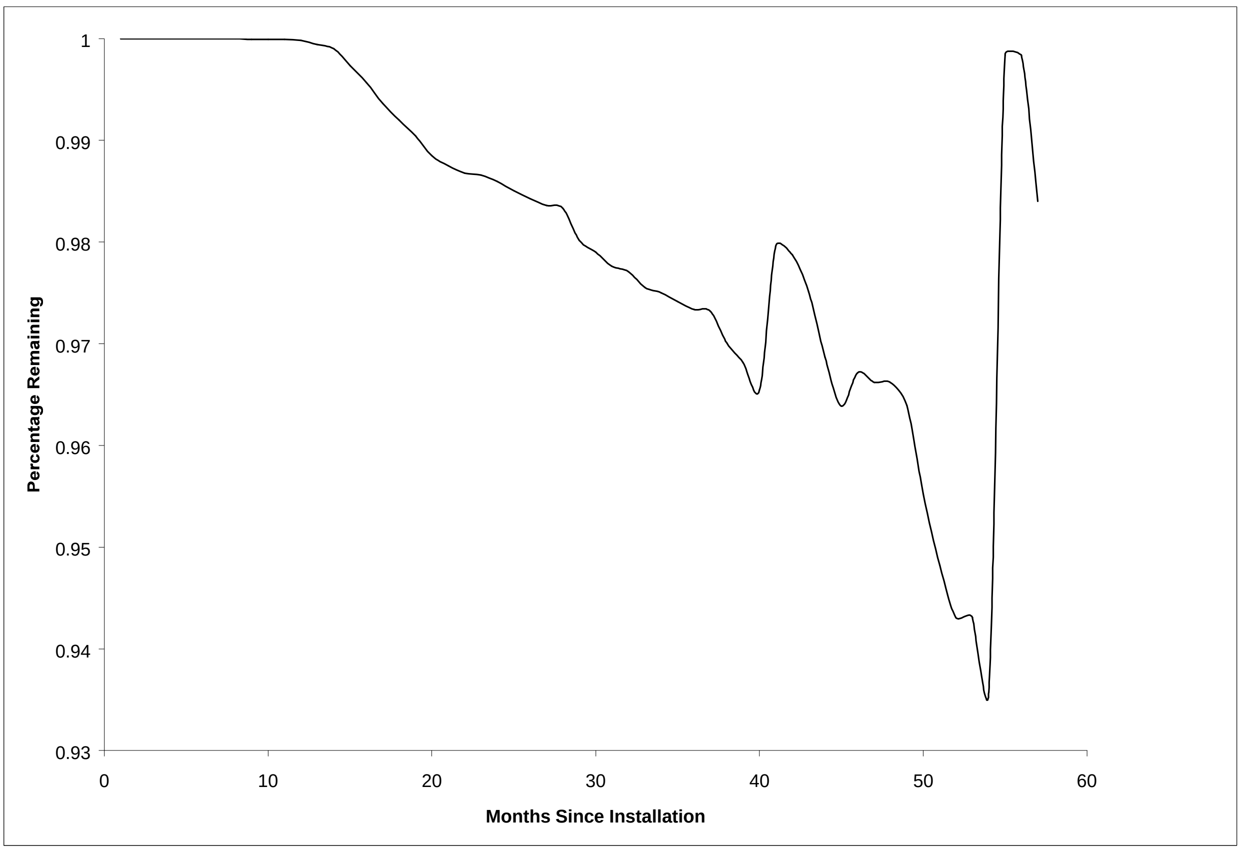


Exhibit 3-7 illustrates the sensitivity of using alternative methods for populating missing failure/removal dates. Again, we are only plotting the first 40 months for the reasons stated above. In addition, we are not including the equipment in the estimate of the survival function if the survey date occurred prior to month M.

Overall, the survival functions do not vary significantly across the four missing failure date approaches. We have selected the approach of populating missing failure dates with a random date, for conducting our analyses. We have selected this approach for three reasons. First, the random date falls between the earliest and latest dates. Second, the random date is smoother than the others. Third, the random date does not force multiple failure/removals to occur all on the same day, as the other methods would.

Exhibit 3-7
Comparison of Approaches for Populating Missing Failure Dates
L23 T8 Measure

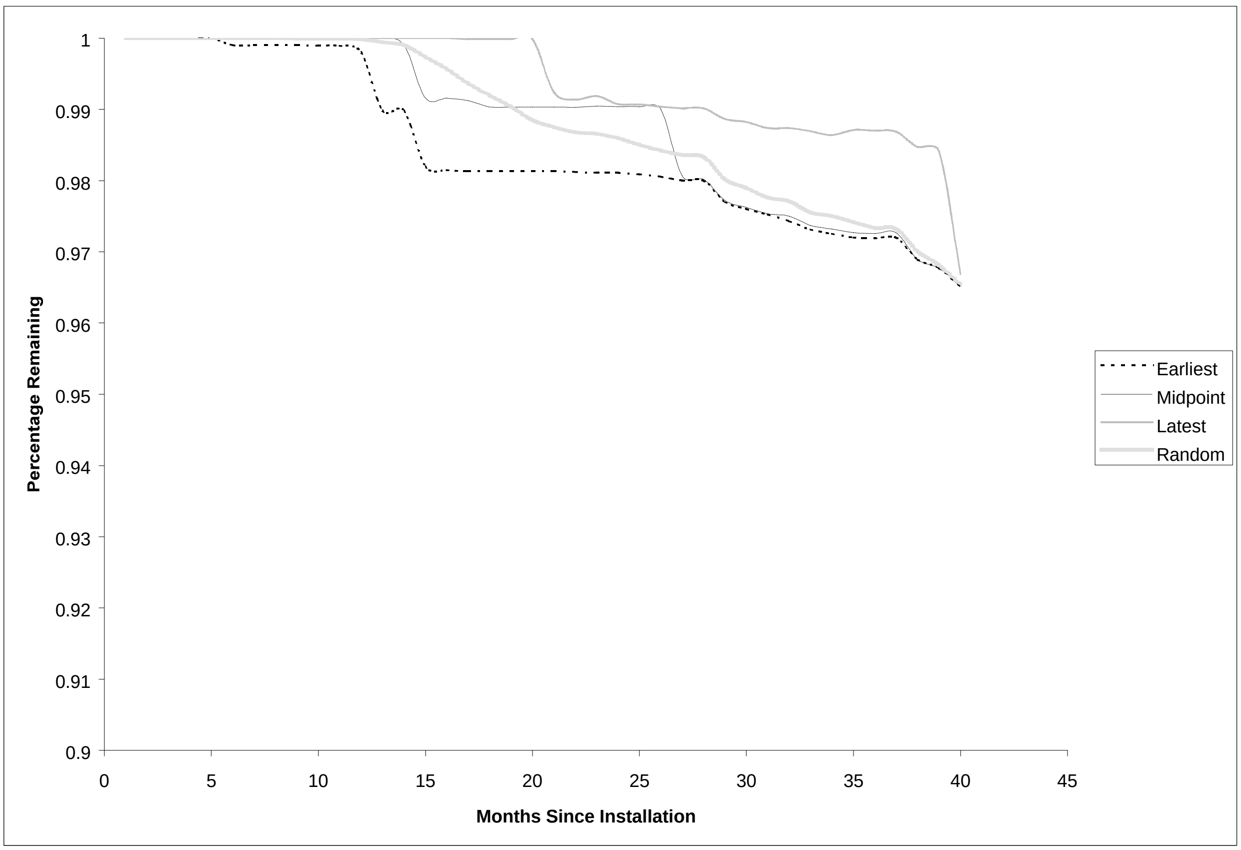


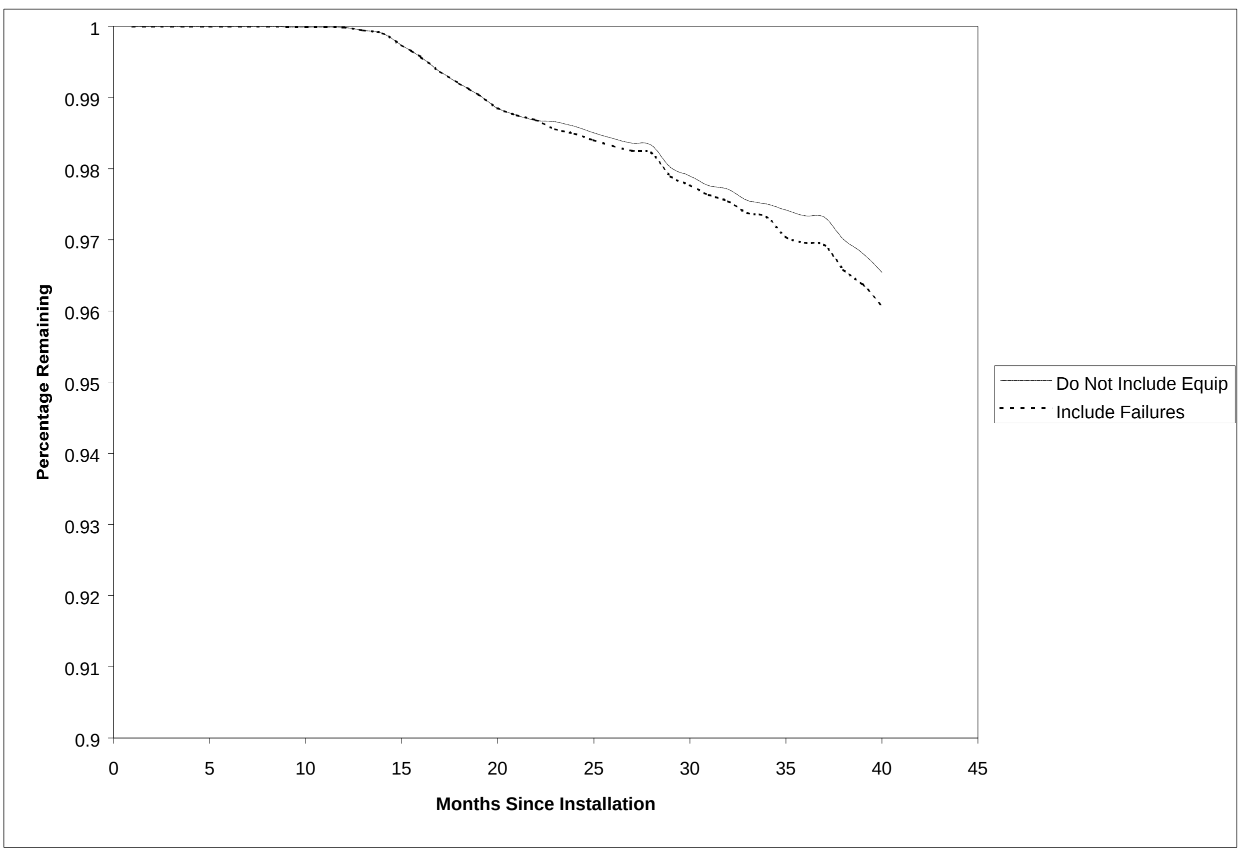
Exhibit 3-8 illustrates the sensitivity of using the two alternative methods for including equipment in the estimate of the empirical survival function if the survey length is less than the month being estimated. Again, these two methods are:

1. Not include the equipment at all, regardless if a failure/removal occurred prior to month M.

2. Only include the equipment if a failure/removal occurred prior to month M, because we know that the equipment is still failed or removed in month M.

Again, we are only plotting the first 40 months, and using a random date to populate missing failure/removal dates. As expected, including equipment if it has failed (option 2), results in a slightly lower survival function. Although this method is clearly biased downward, we see that the survival function is not that sensitive to the method. We have selected the approach of not including the equipment at all, regardless if a failure/removal occurred prior to month M. We feel this is the only unbiased method, and it is not significantly different than the more conservative method of including failed/removed equipment in the calculation.

Exhibit 3-8
Comparison of Approaches for Including Equipment with Survey Lengths Less than Month Estimated
L23 T8 Measure

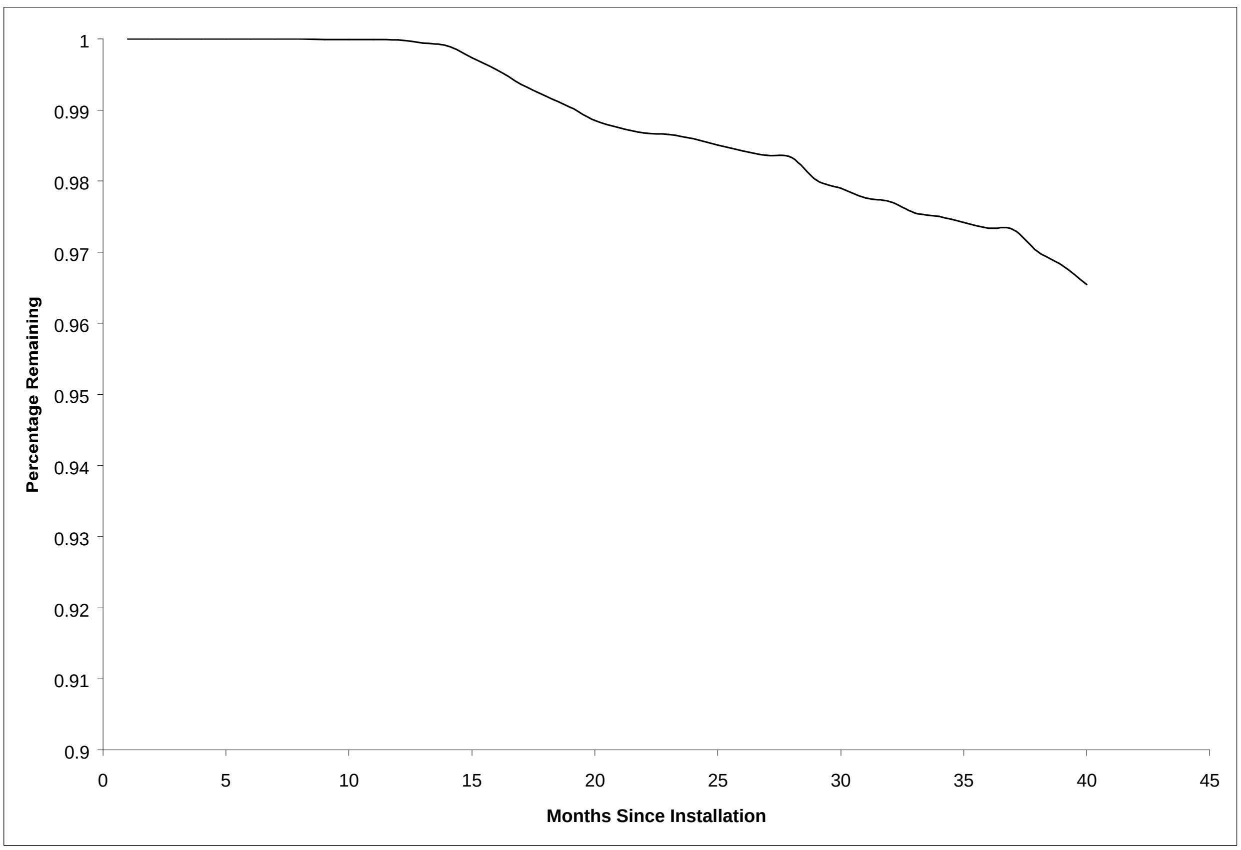


Finally, Exhibit 3-9 presents the final empirical survival function developed for the L23 T8 measure. This survival function is based on the following assumptions:

1. For missing failure/removal dates, generate a random date (based on a uniform distribution) between the date the retention panel was created and date the follow-up survey was conducted.

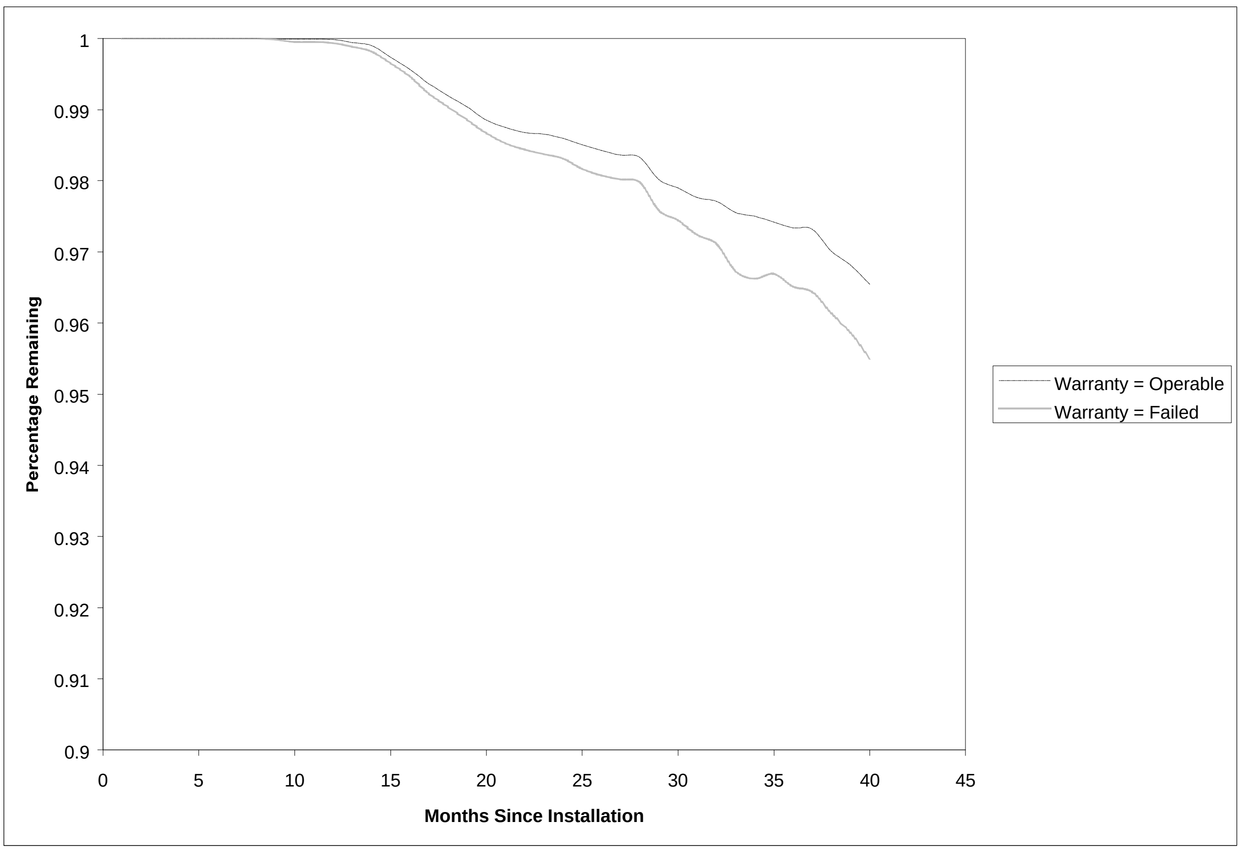
2. To estimate the percentage of equipment operable and in place in month M, do not include the equipment if the survey length is less than month M, regardless if a failure/removal occurred prior to month M.

Exhibit 3-9
Final Empirical Survival Function
L23 T8 Measure



One other interesting issue is that of warrantied equipment. As stated above, failed equipment that is replaced under warranty counts as if it is still operable and in place. For the L23 T8 measure, 30 percent of the failed equipment was replaced under warranty. Exhibit 3-10 compares how the empirical survival function for the L23 T8 measure would change if warrantied equipment did not count as operable and in place.

Exhibit 3-10
Sensitivity to Warranty
L23 T8 Measure



Exhibits 3-11 through 3-13 provide the empirical survival functions for the L37 HID >=176W, L81 HID 251-400W and S22 ASD measures, based on the same assumptions. For the L81 HID 251-400W and S22 ASD measures, the first 40 months of the survival function is plotted. For L37 HID >=176W, however, we have shown the first 55 months. In month 48, one site removed all 12 of their L37 HID >=176W measures, as is illustrated by the large drop in the empirical survival function. Because there was sufficient data to support the empirical function out to 55 months, and because of the significant event that occurred in month 48, we have shown more months of data in Exhibit 3-11.

Exhibit 3-11
Final Empirical Survival Function
L37 HID >=176W Measure

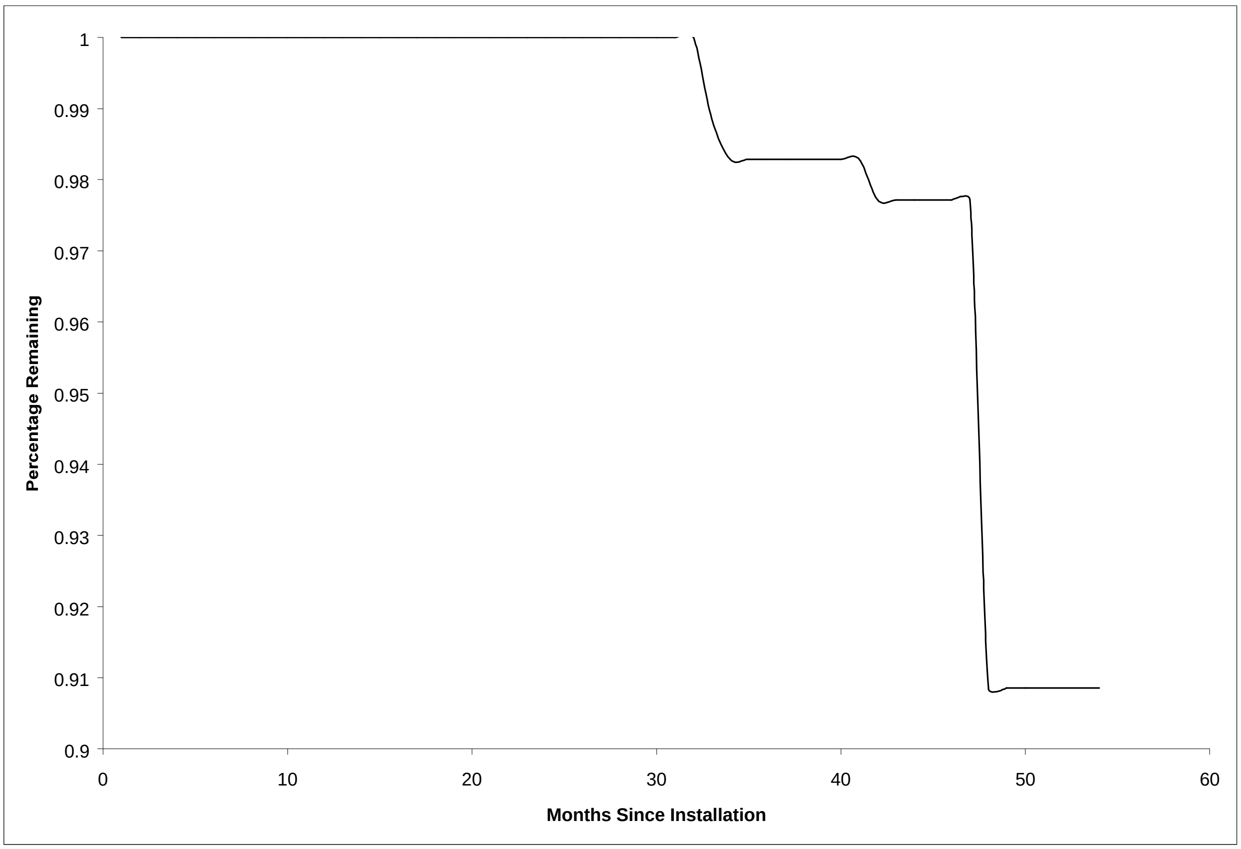


Exhibit 3-12
Final Empirical Survival Function
L81 HID 251-400W Measure

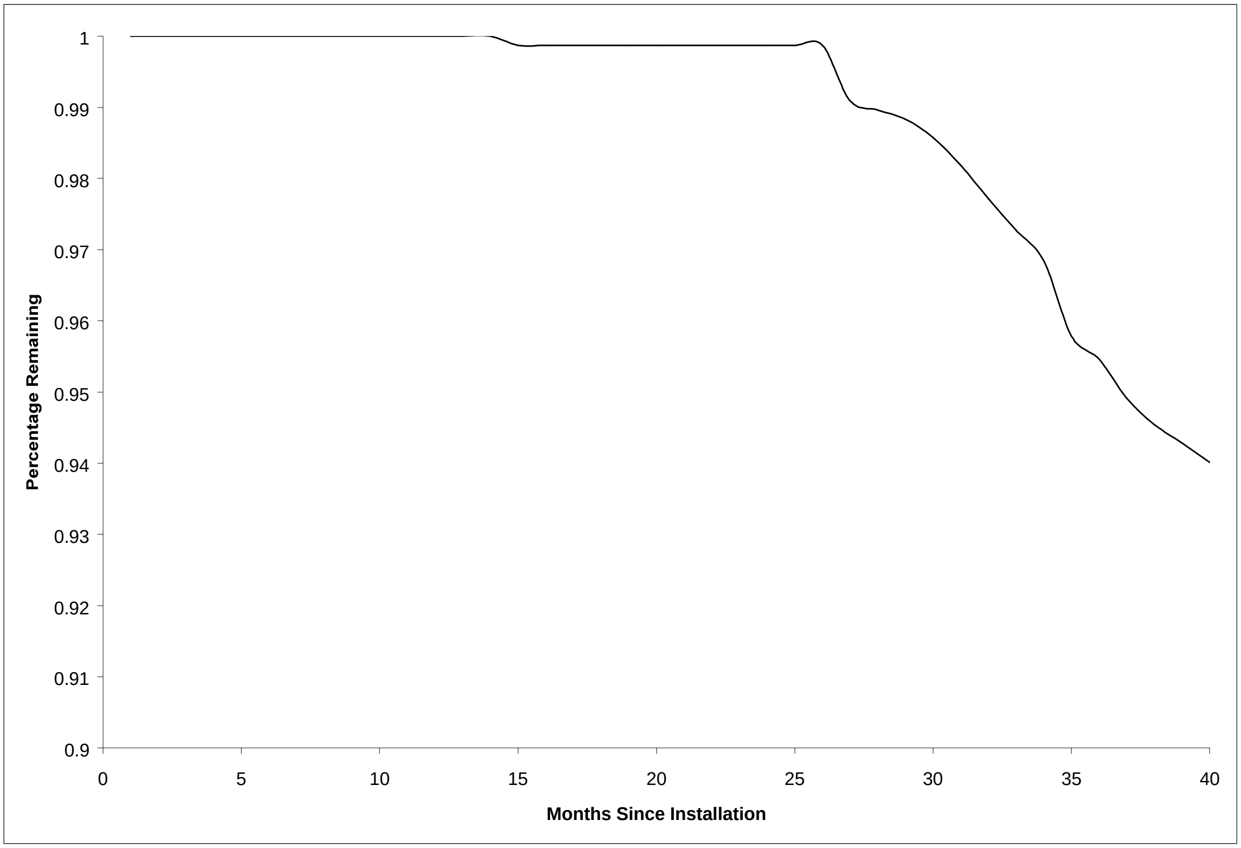
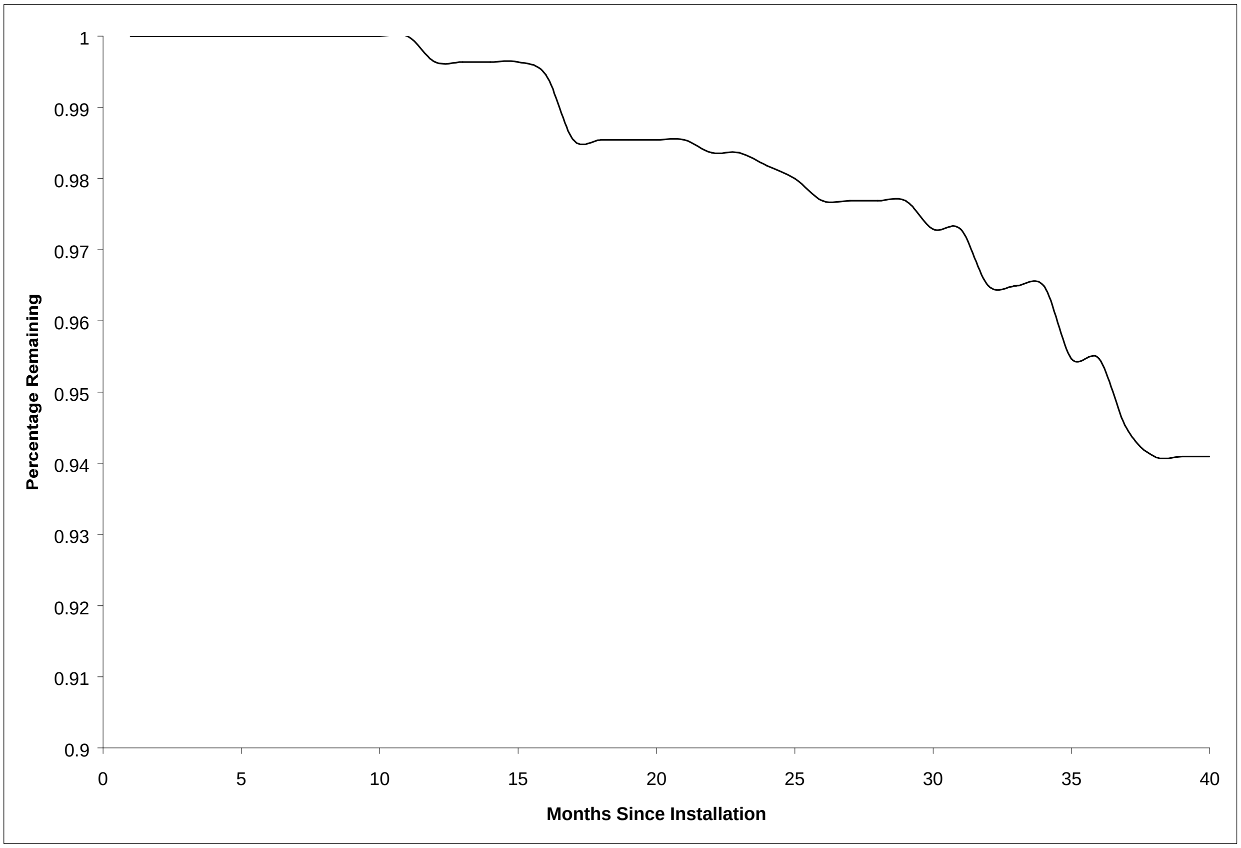


Exhibit 3-13
Final Empirical Survival Function
S22 ASD Measure



3.4 TREND LINES

Based on the empirical survival functions presented above, a trend line was developed to estimate the survival function over the life of the measure, and estimate the measure's EUL. As discussed above, only the first 40 months of the empirical survival functions were used. This was done for the L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD measures, however, 55 months of data were used for the L37 HID >=176W measure, as discussed above.

Two trend lines were estimated using linear regression:

- The first trend line was assumed to have a linear relationship over time. Therefore, the trend line was developed using a linear regression with the percentage of equipment operable and in place as the dependent variable, and the month as the independent variable.

- The second trend line was assumed to follow the exponential distribution, which is one of the most common distributions used in survival analysis. The trend line was also used with linear regression by making a transformation on the percentage of equipment operable and in place. The natural log of the percentage of equipment operable and in place was used as the dependent variable, and the month as the independent variable.

The results of these analysis are provided below.

Linear Trends – L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD

Exhibit 3-14 provides the resulting survival function assuming a linear trend for the L23 T8 measure. Exhibit 3-15 compares this linear survival function with the empirical function developed above, for the first 40 months of the measure's life. This exhibit illustrates how well the linear trend compares to the empirical function during the earlier parts of the measure's life.

Exhibit 3-14
Survival Function Based on a Linear Trendline
L23 T8 Measure

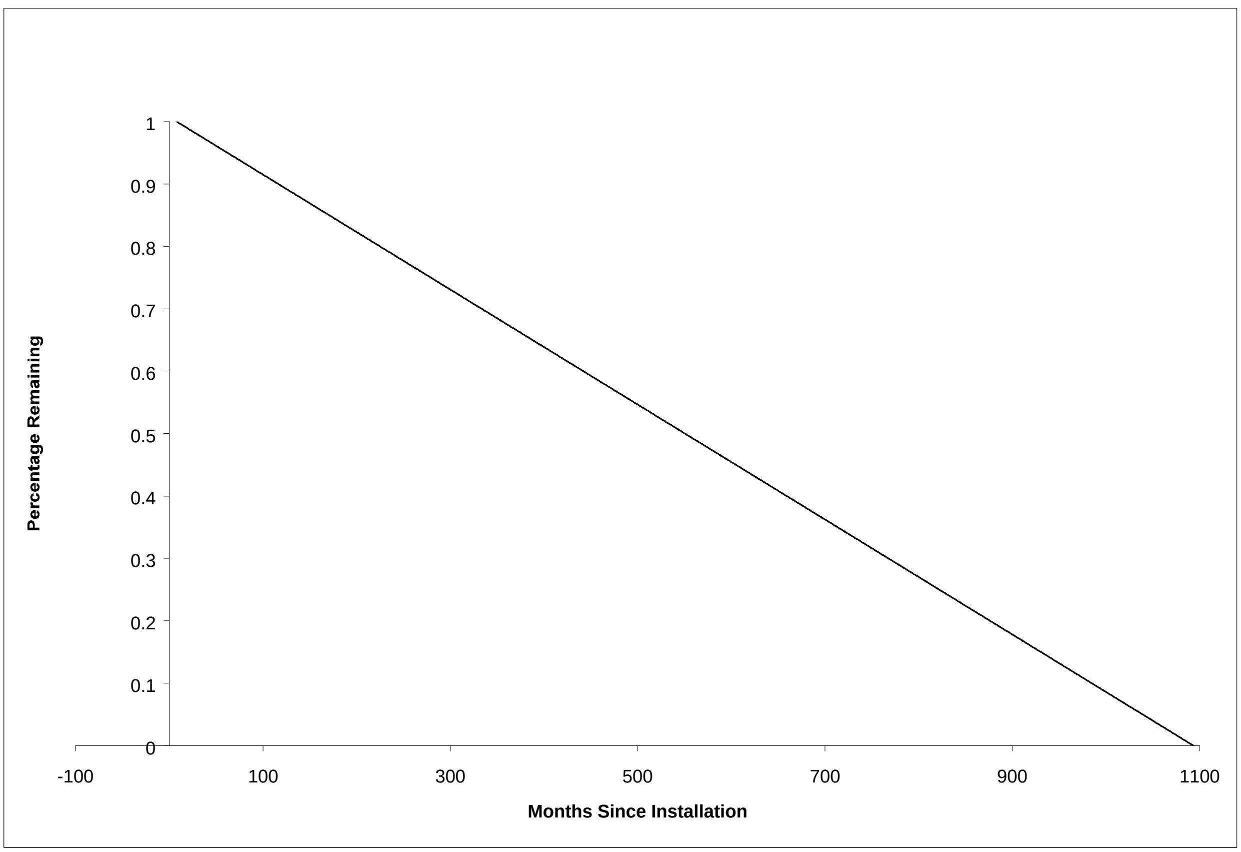
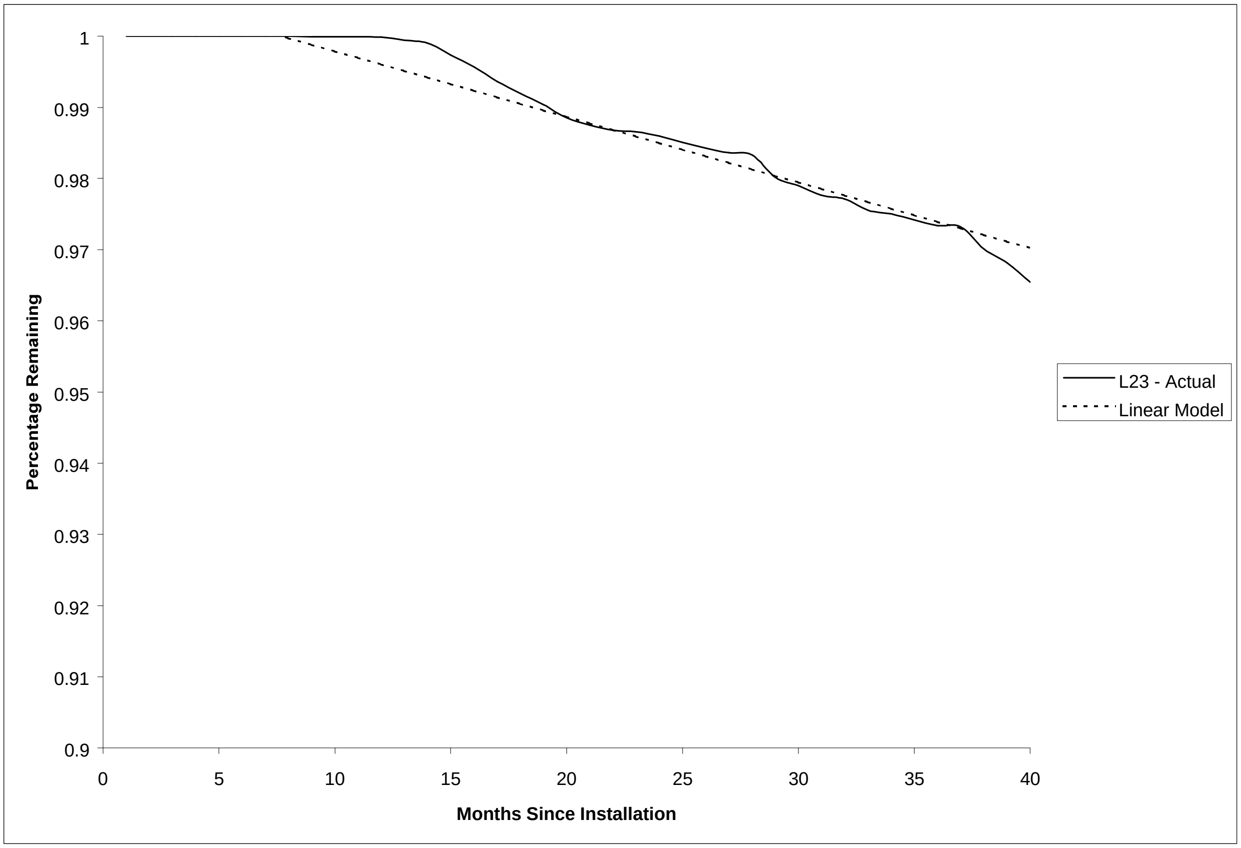


Exhibit 3-15
Comparison of Empirical Survival Function and Linear Trendline
L23 T8 Measure



Similarly, Exhibits 3-16 through 3-21 provide the linear survival functions, and comparisons to the empirical survival functions for the L37 HID >=176W, L81 HID 251-400W and S22 ASD measures. As discussed earlier, 55 months are shown for L37 HID >=176W. The large drop off in month 48, which is due to one customer removing all 12 of the HIDs, caused a large shift in the slope of the trend line. The slope of the trendline is –0.0015, versus only -0.0004 had we analyzed only the first 40 months (prior to the large customer removal.) Clearly, the results for the L37 HID >=176W measure are extremely sensitive to this one customer's action, as we will discuss in more detail later.

Exhibit 3-16
Survival Function Based on a Linear Trendline
L37 HID >=176W Measure

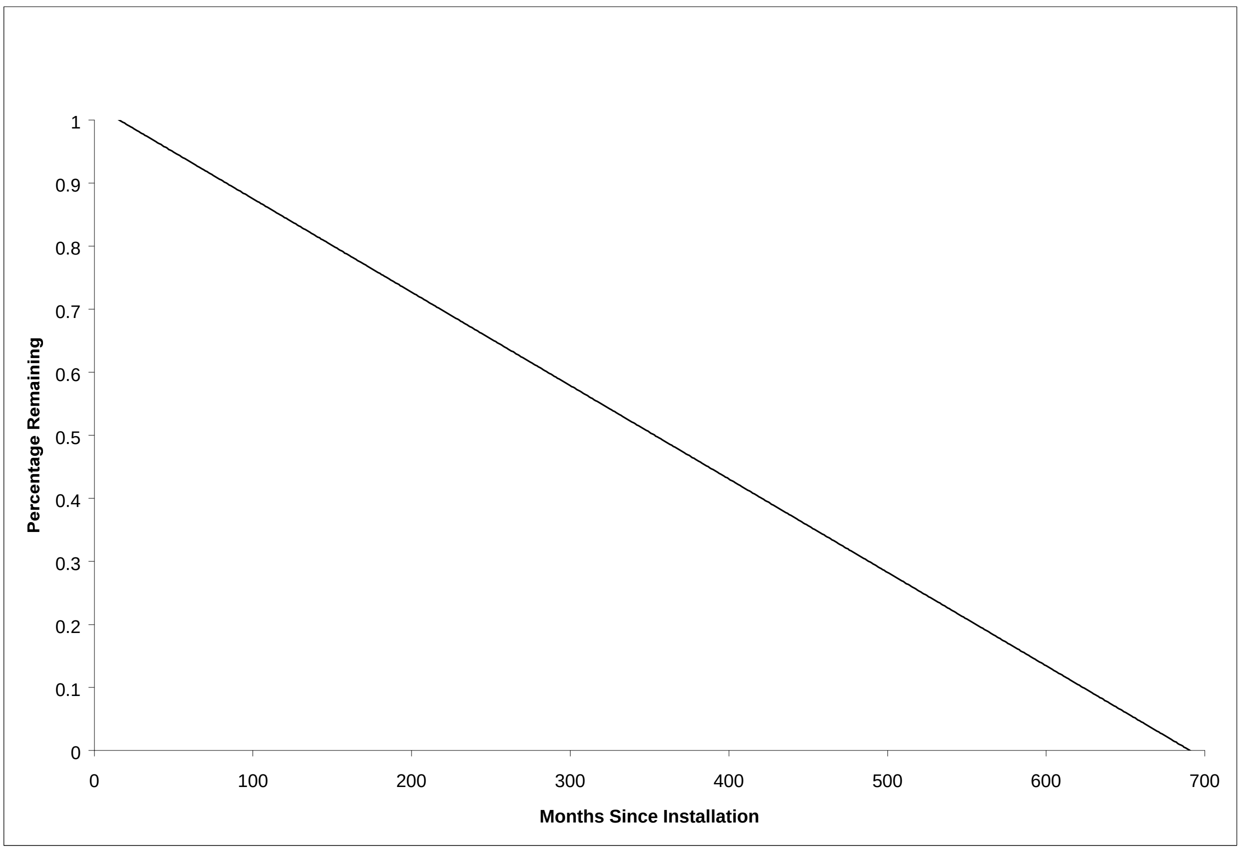


Exhibit 3-17
Comparison of Empirical Survival Function and Linear Trendline
L37 HID >=176W Measure

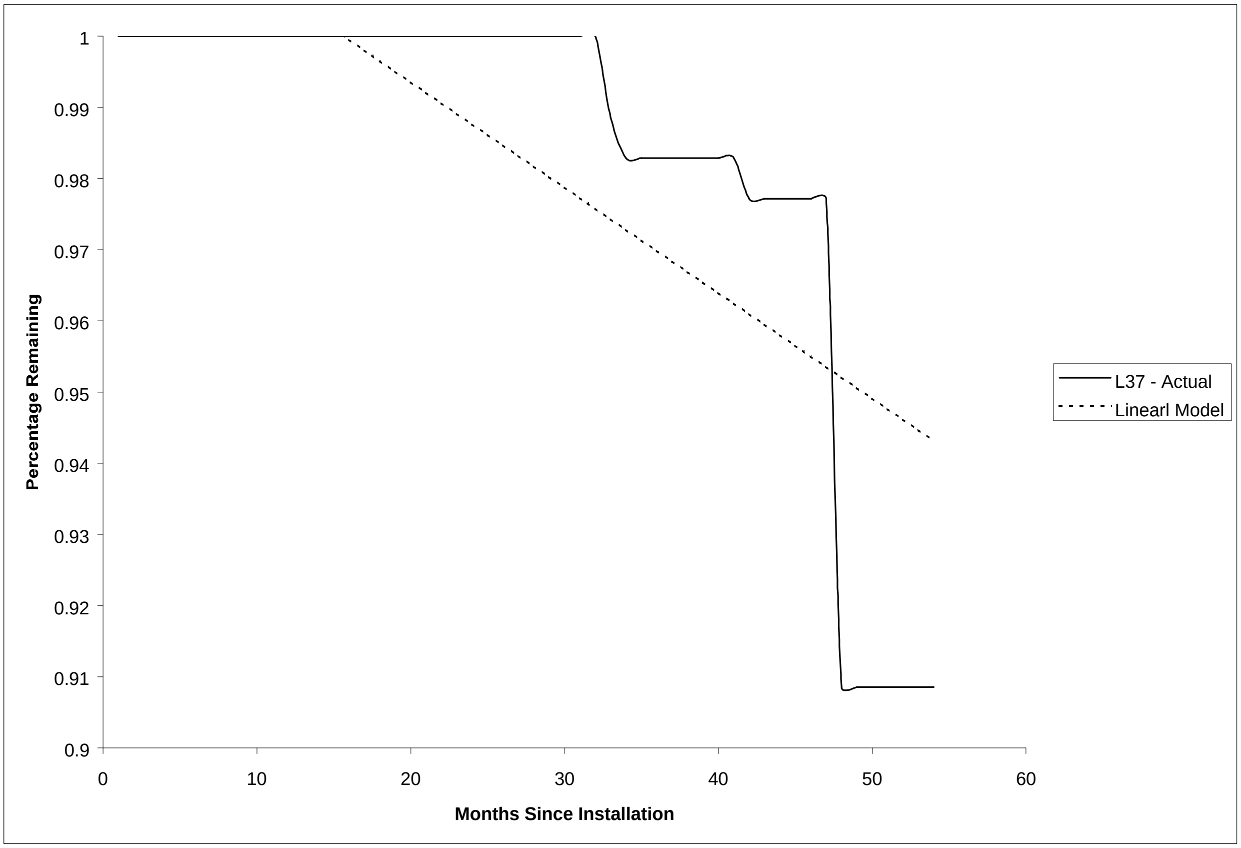


Exhibit 3-18
Survival Function Based on a Linear Trendline
L81 HID 251-400W Measure

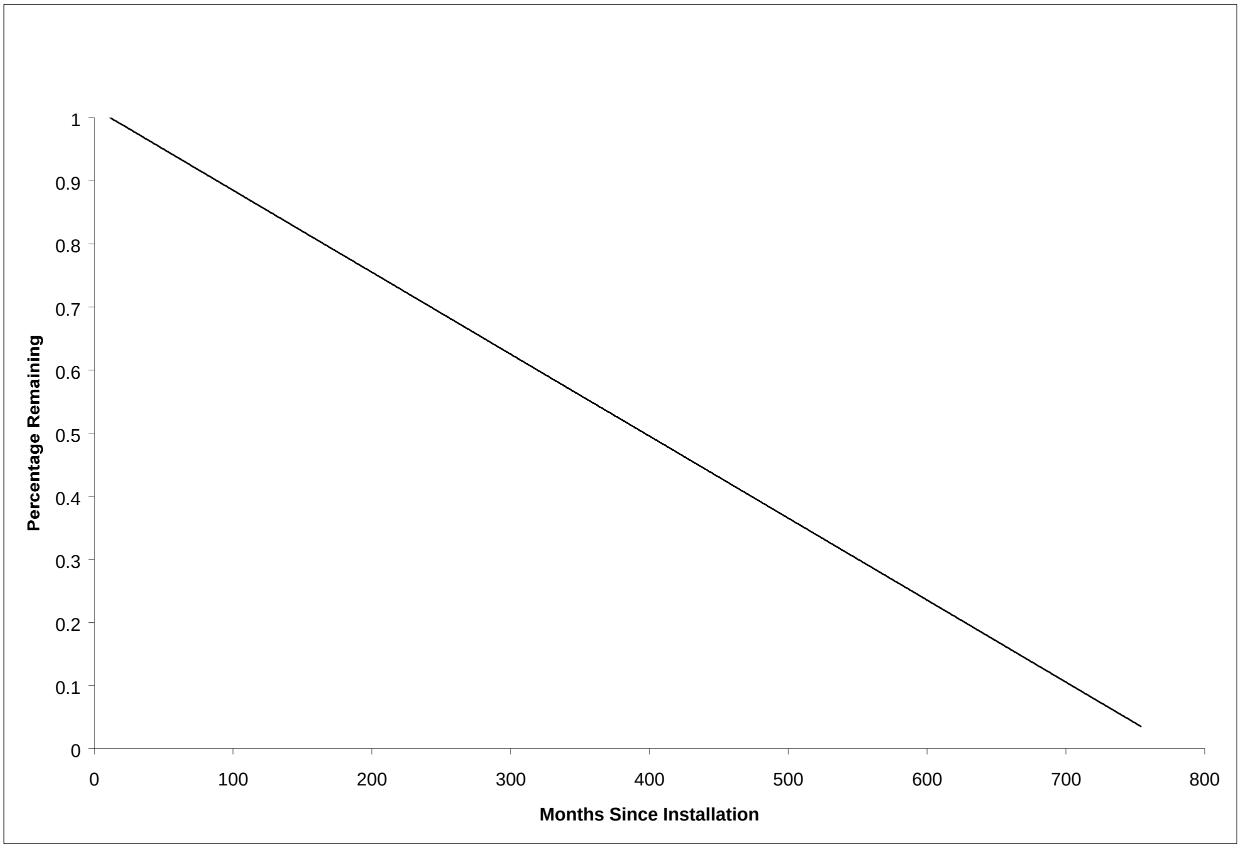


Exhibit 3-19
Comparison of Empirical Survival Function and Linear Trendline
L81 HID 251-400W Measure

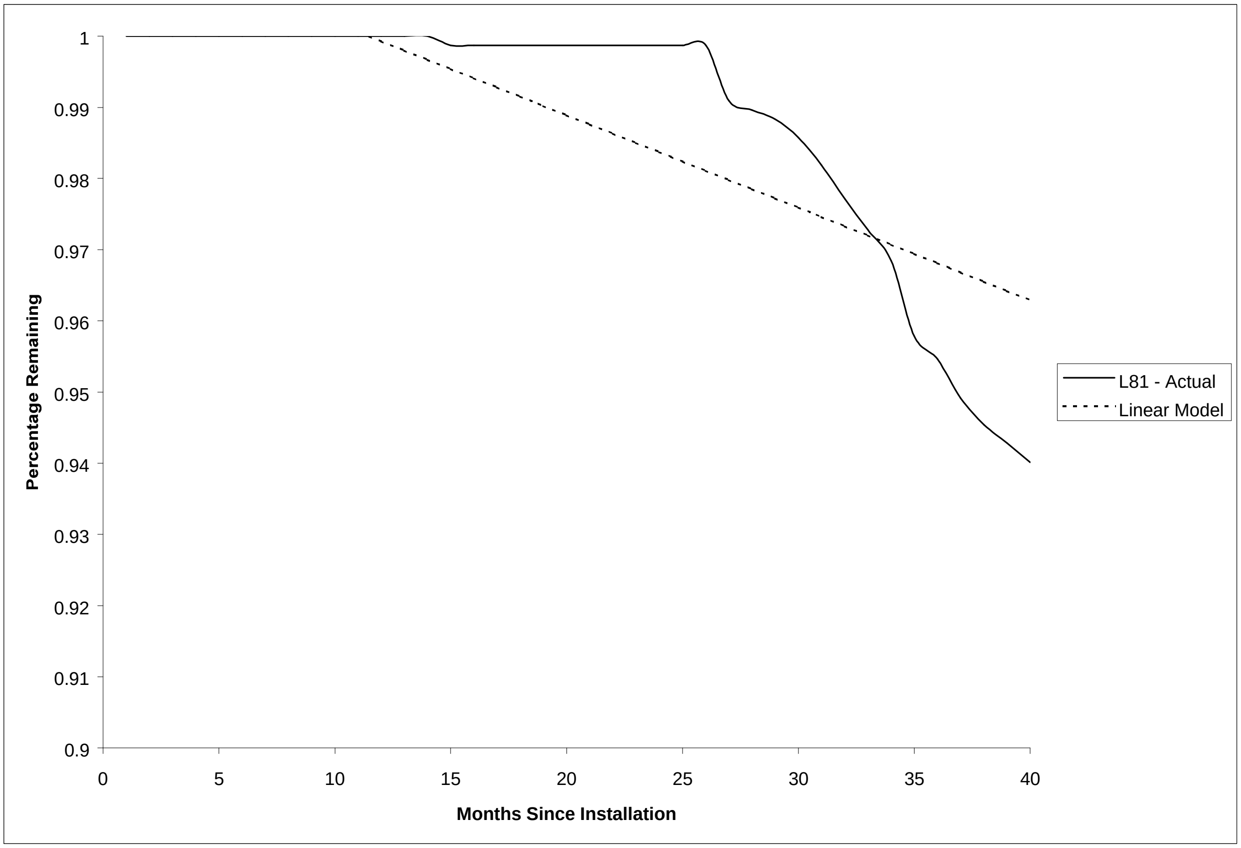


Exhibit 3-20
Survival Function Based on a Linear Trendline
S22 ASD Measure

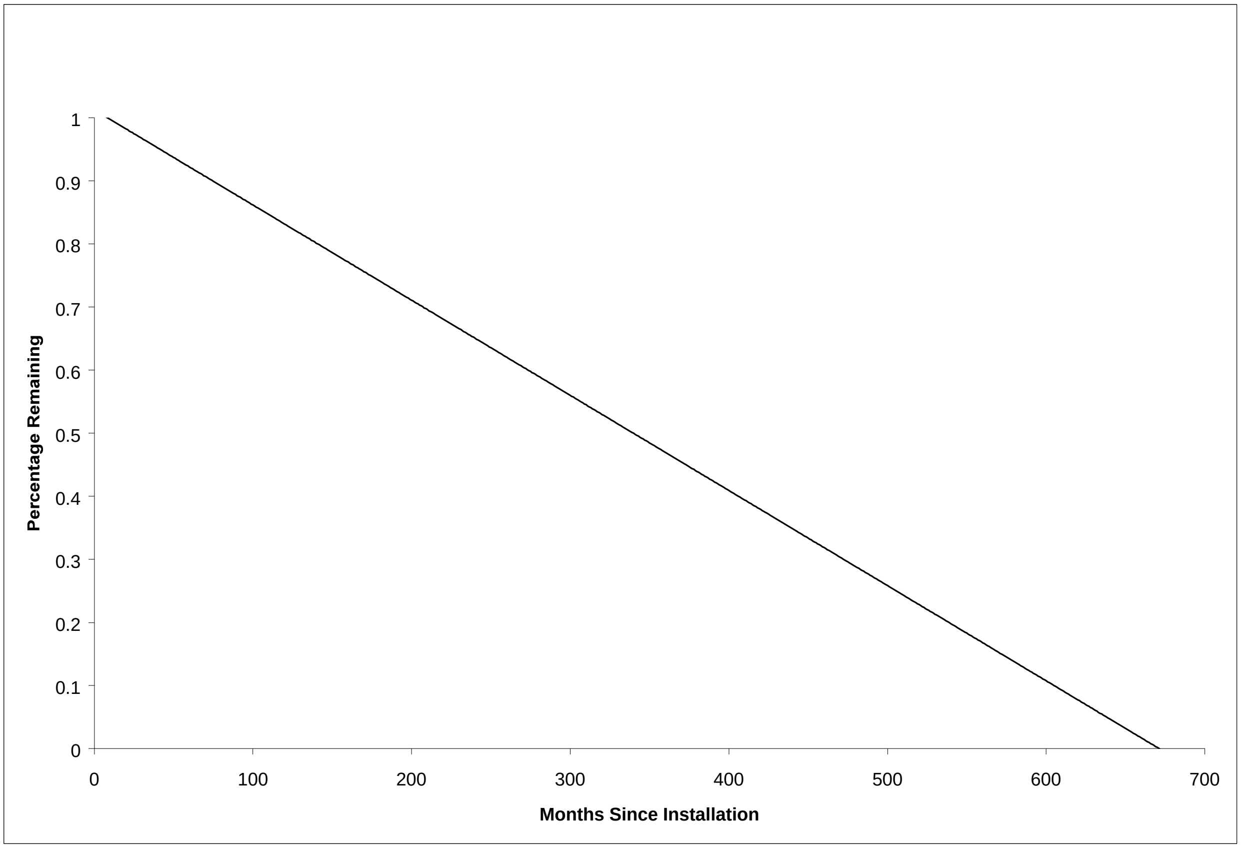
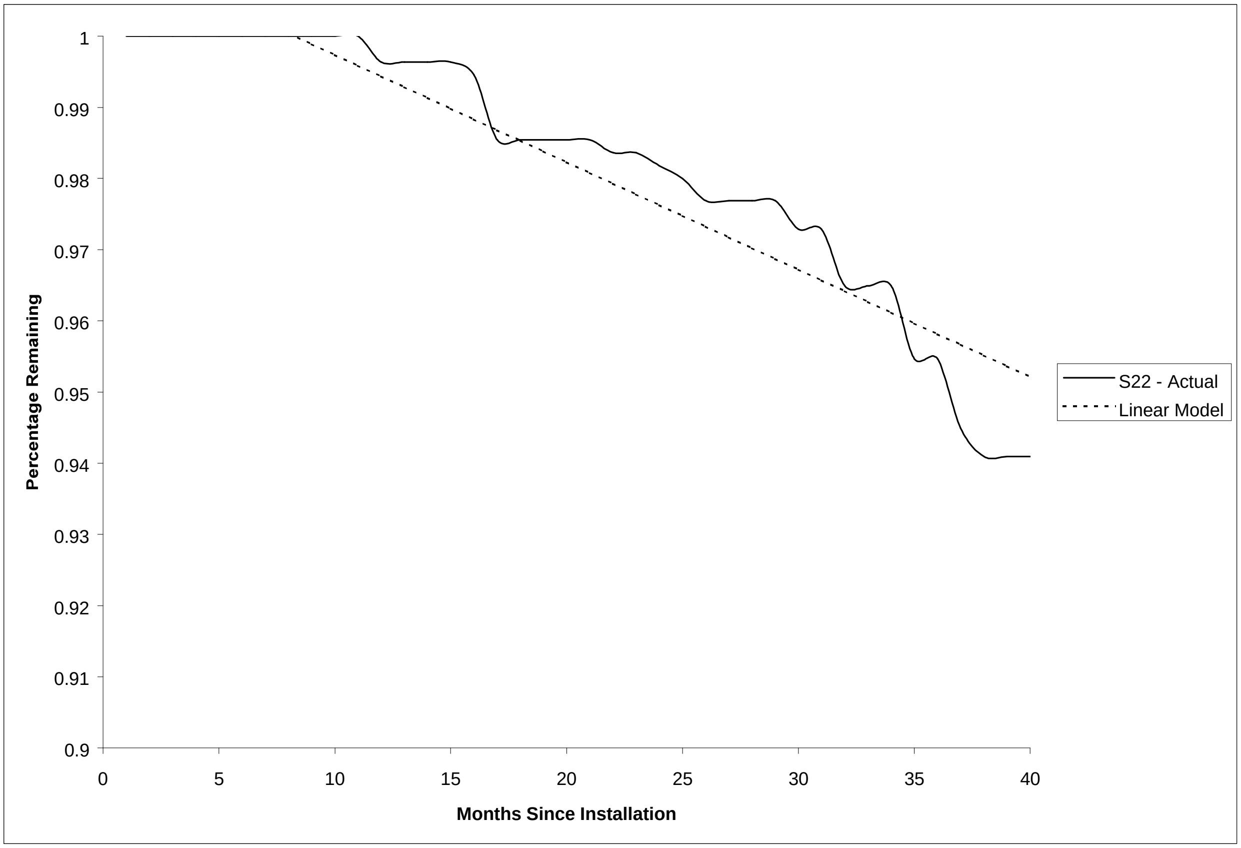


Exhibit 3-21
Comparison of Empirical Survival Function and Linear Trendline
S22 ASD Measure



The results of the linear regressions are provided in Exhibit 3-22 for each of the four measures. Also provided in Exhibit 3-24 is the estimated EUL for each measure. For a linear survival function, the EUL (median life) is calculated as:

EUL = (0.5 – intercept) / slope

Exhibit 3-22
Regression Results of Linear Trendline
and Resulting Ex Post EUL Estimates

Measure	Measure Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	1.01	1,193	-0.0009	-25.67	46
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	1.01	279	-0.0013	-8.39	33
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	1.02	184	-0.0015	-8.59	29
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	1.01	490	-0.0015	-17.16	28

Clearly, the results of the linear trendline estimate indicate that the ex post EUL estimate is significantly larger than the ex ante estimates (which are all 16 years). Each of these results would easily reject the ex ante estimate at the 80 percent confidence level.

Exponential Trends – L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD

Exhibit 3-23 provides the resulting survival function assuming an exponential trend for the L23 T8 measure. Exhibit 3-24 compares this exponential survival function with the empirical function developed above, for the first 40 months of the measure's life. This exhibit illustrates how well the exponential trend compares to the empirical function during the earlier parts of the measure's life.

Exhibit 3-23
Survival Function Based on an Exponential Trendline
L23 T8 Measure

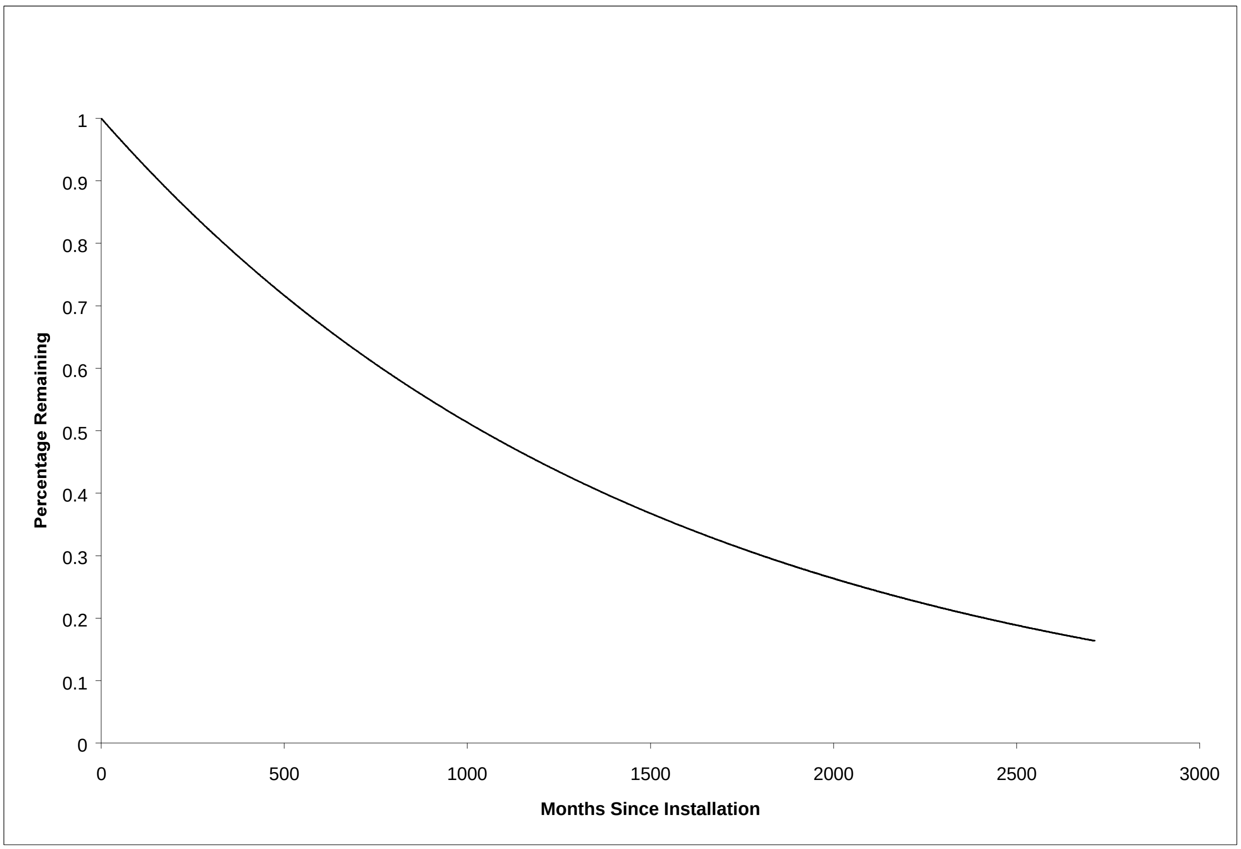
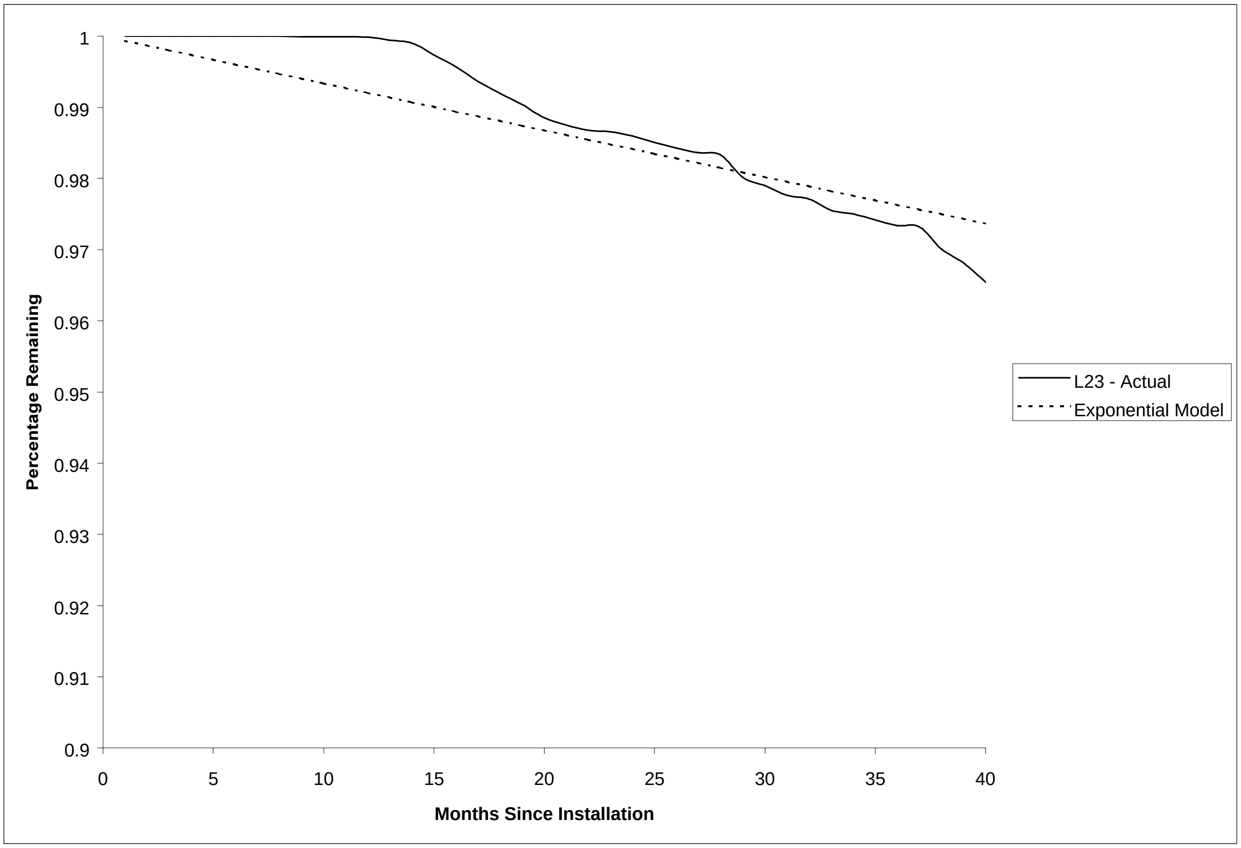


Exhibit 3-24
Comparison of Empirical Survival Function and Exponential Trendline
L23 T8 Measure



Similarly, Exhibits 3-25 through 3-30 provide the exponential survival functions, and comparisons to the empirical survival functions for the L37 HID >=176W, L81 HID 251-400W and S22 ASD measures. Again, the L37 HID >=176W measure result was very sensitive to the one customer removing their HIDs. The resulting exponential parameter (λ, which is the reciprocal of the mean) is –0.0009, versus only -0.0004 had we analyzed only the first 40 months (prior to the large customer removal.)

Exhibit 3-25
Survival Function Based on an Exponential Trendline
L37 HID >=176W Measure

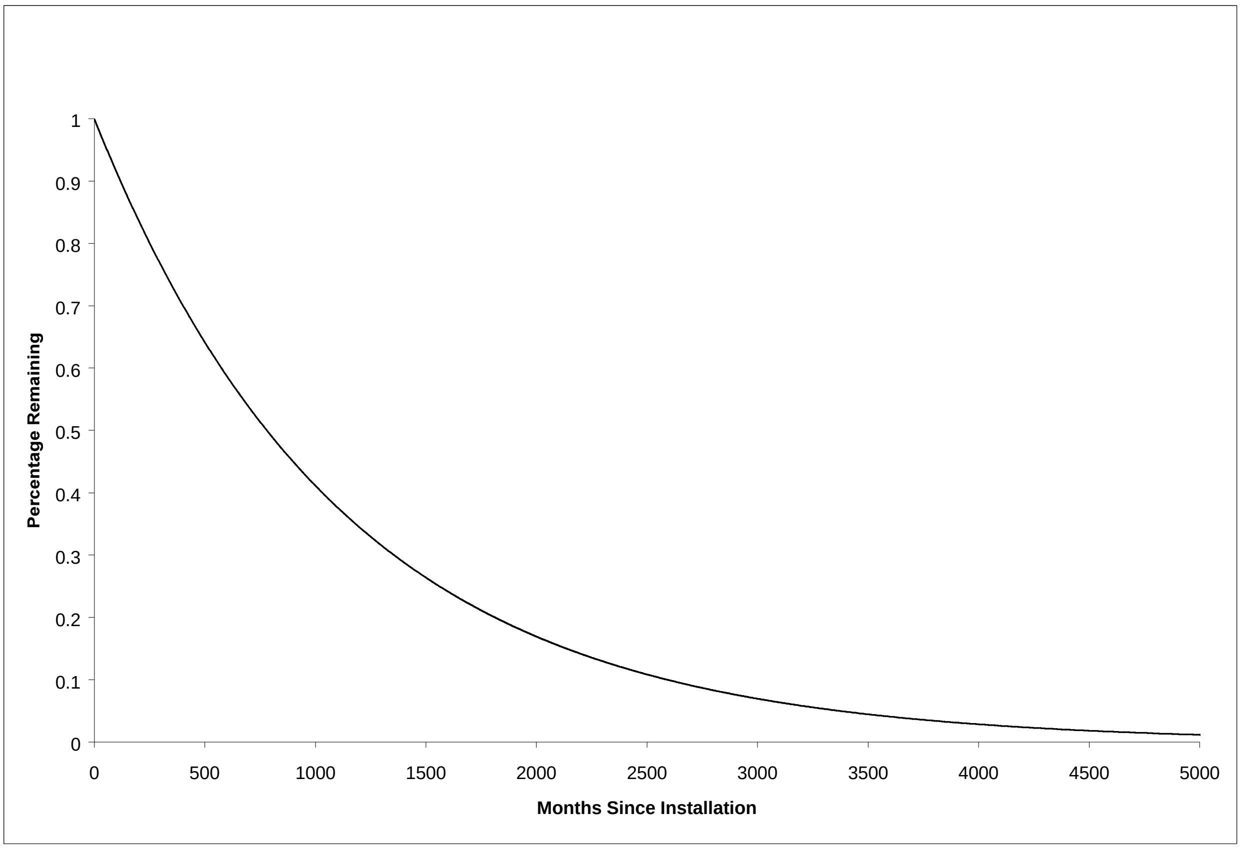


Exhibit 3-26
Comparison of Empirical Survival Function and Exponential Trendline
L37 HID >=176W Measure

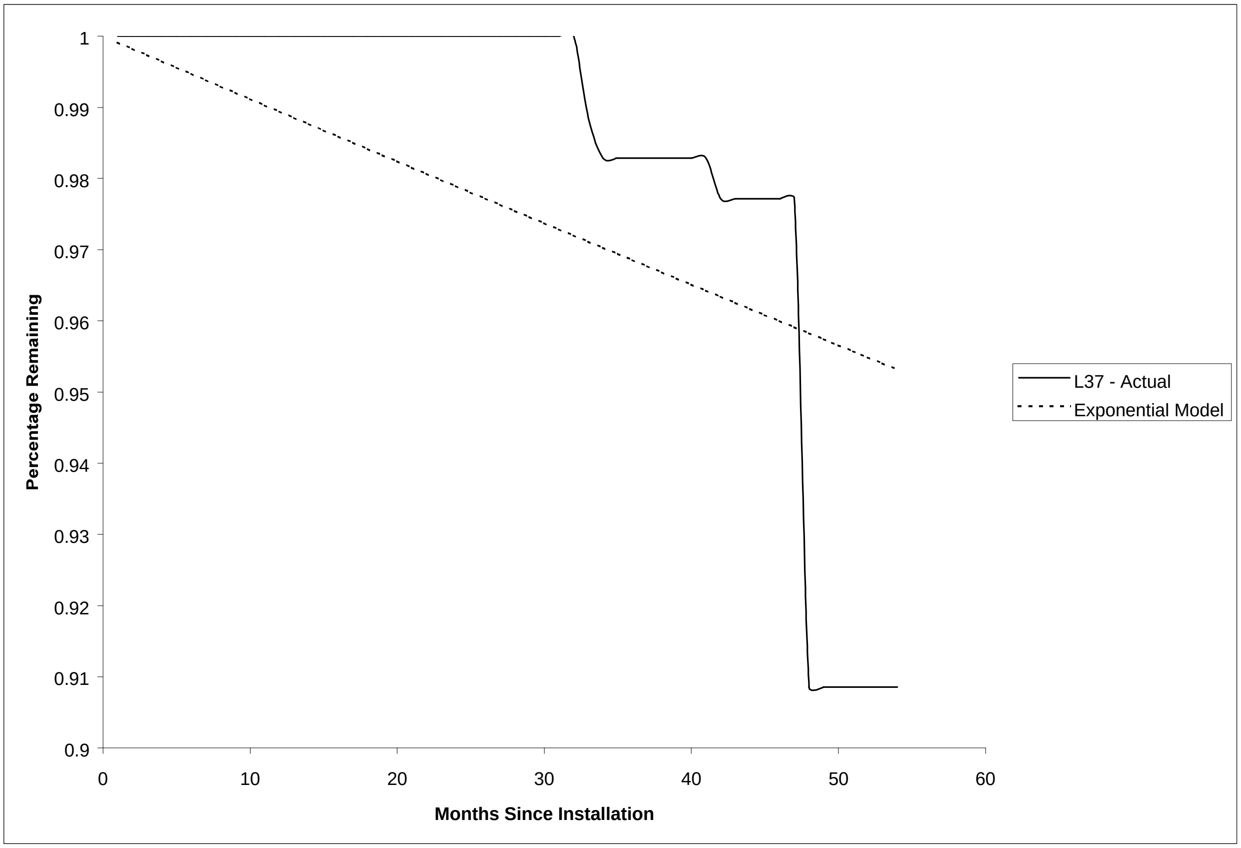


Exhibit 3-27
Survival Function Based on an Exponential Trendline
L81 HID 251-400W Measure

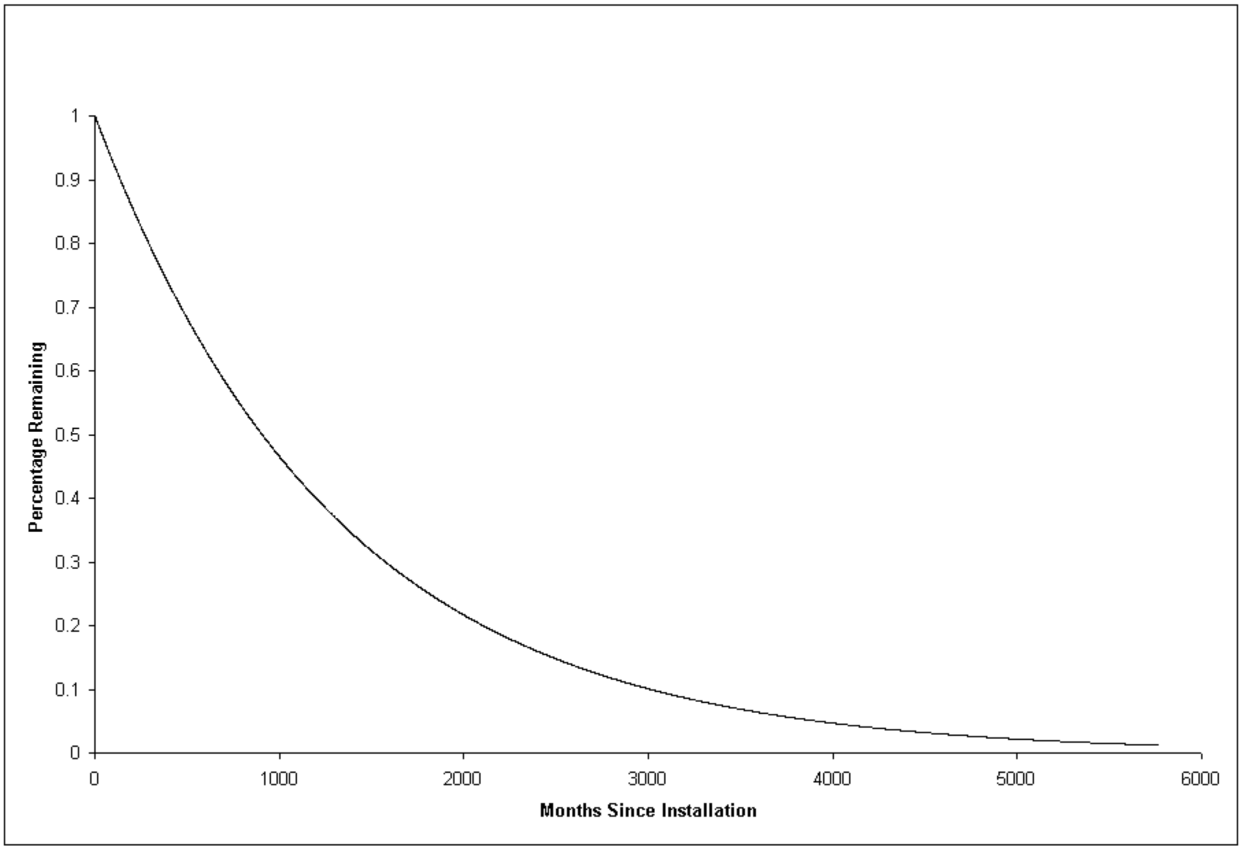


Exhibit 3-28
Comparison of Empirical Survival Function and Exponential Trendline
L81 HID 251-400W Measure

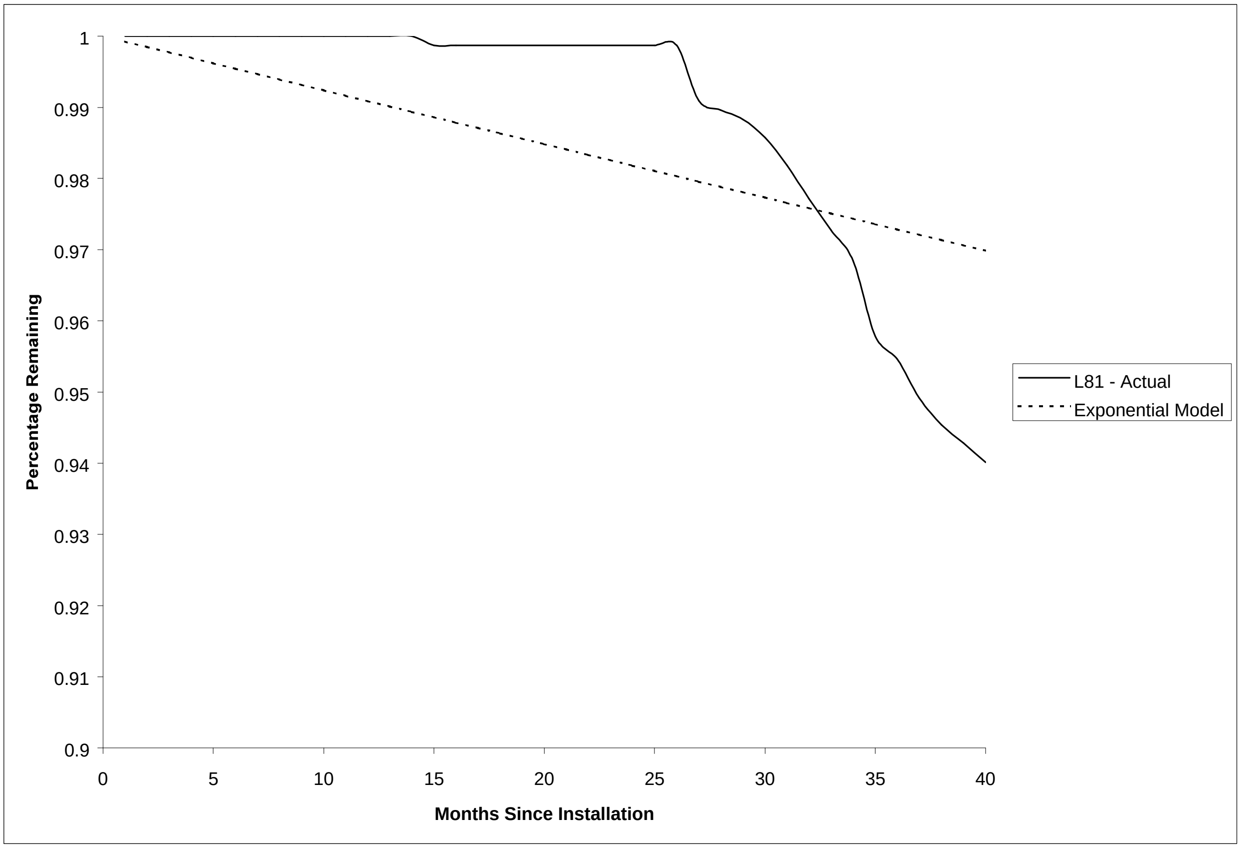


Exhibit 3-29
Survival Function Based on an Exponential Trendline
S22 ASD Measure

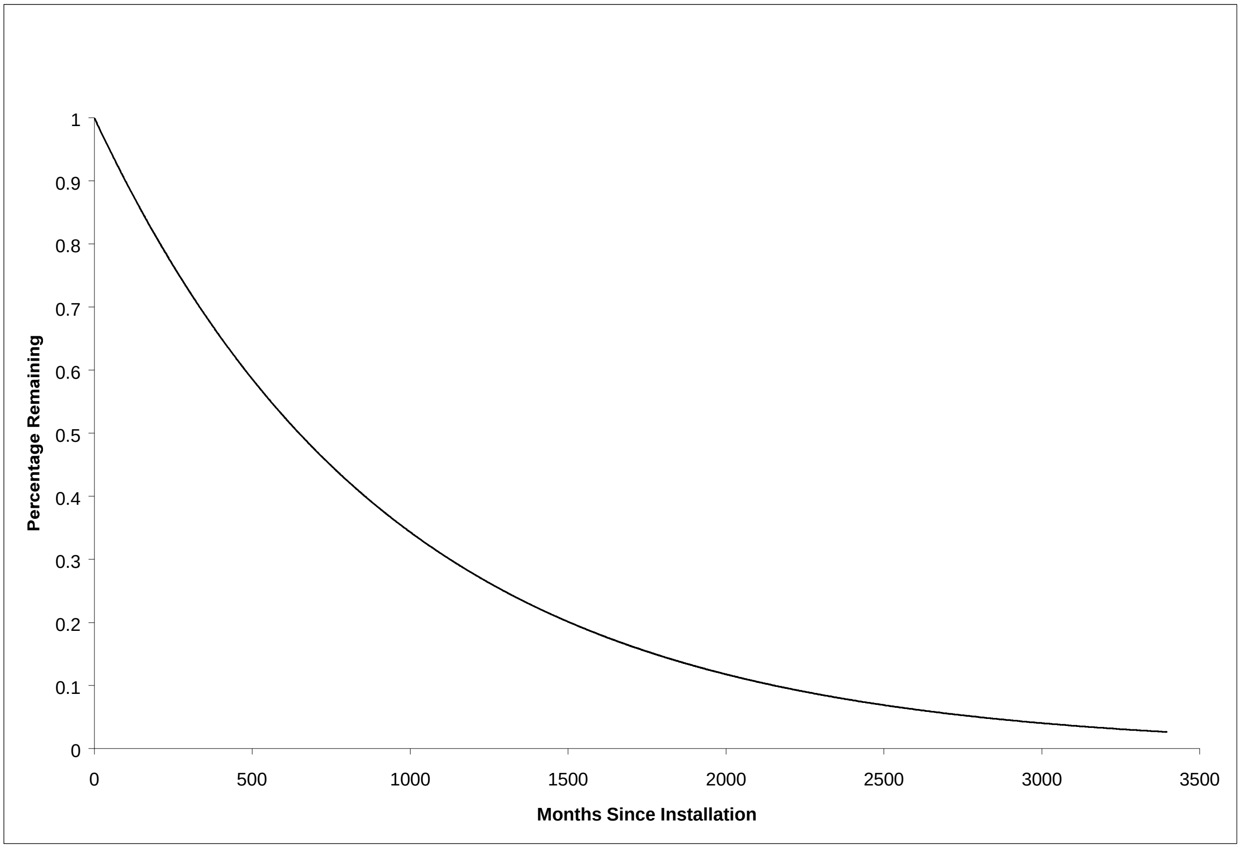
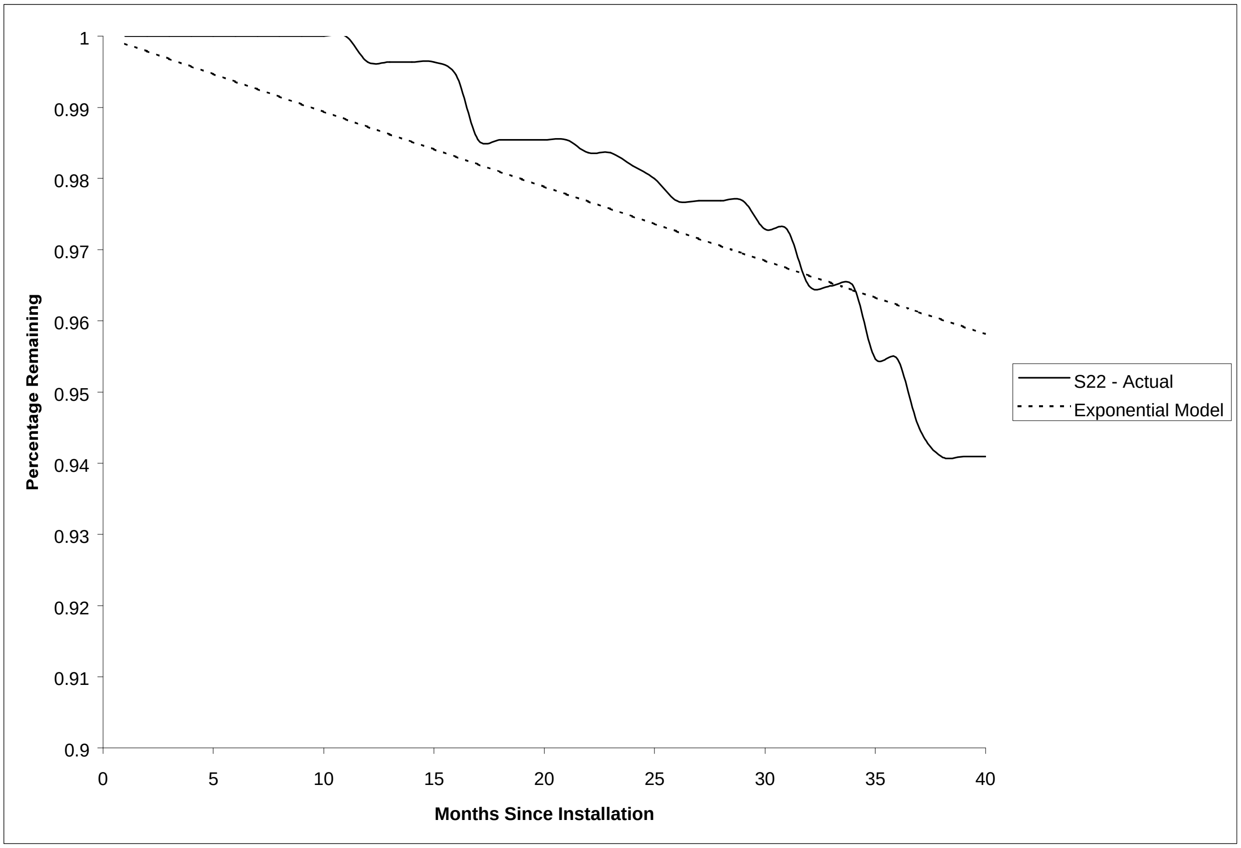


Exhibit 3-30
Comparison of Empirical Survival Function and Exponential Trendline
S22 ASD Measure



The results of the exponential regressions are provided in Exhibit 3-31 for each of the four measures. Also provided in Exhibit 3-31 is the estimated EUL for each measure. For an exponential survival function, the EUL (median life) is calculated as:

$$EUL = \ln(2) / slope$$

Exhibit 3-31
Regression Results of Exponential Trendline and Resulting Ex Post EUL Estimates

Measure	Measure Description	Slope	t-Statistic	EUL
L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	0.0007	22.33	87
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	0.0008	8.26	76
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	0.0009	8.68	65
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	0.0011	17.27	54

The results of the exponential trendline estimates are even more dramatic than for the linear trendline estimates. Again, these results clearly indicate that the ex post EUL estimate is significantly larger than the ex ante estimates (which are all 16 years). Each of these results would easily reject the ex ante estimate at the 80 percent confidence level.

3.5 CLASSICAL SURVIVAL ANALYSIS

This final step in our approach is founded on applying classical survival analysis techniques to the retention data in order to develop a survival function. Using the SAS System and the SAS companion guide, “Survival Analysis Using the SAS System,” we have modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case (except for the gamma distribution), we have plotted the resulting distribution and visually compared it to the empirical functions developed above. Furthermore, we have used the resulting survival function to estimate the EUL.

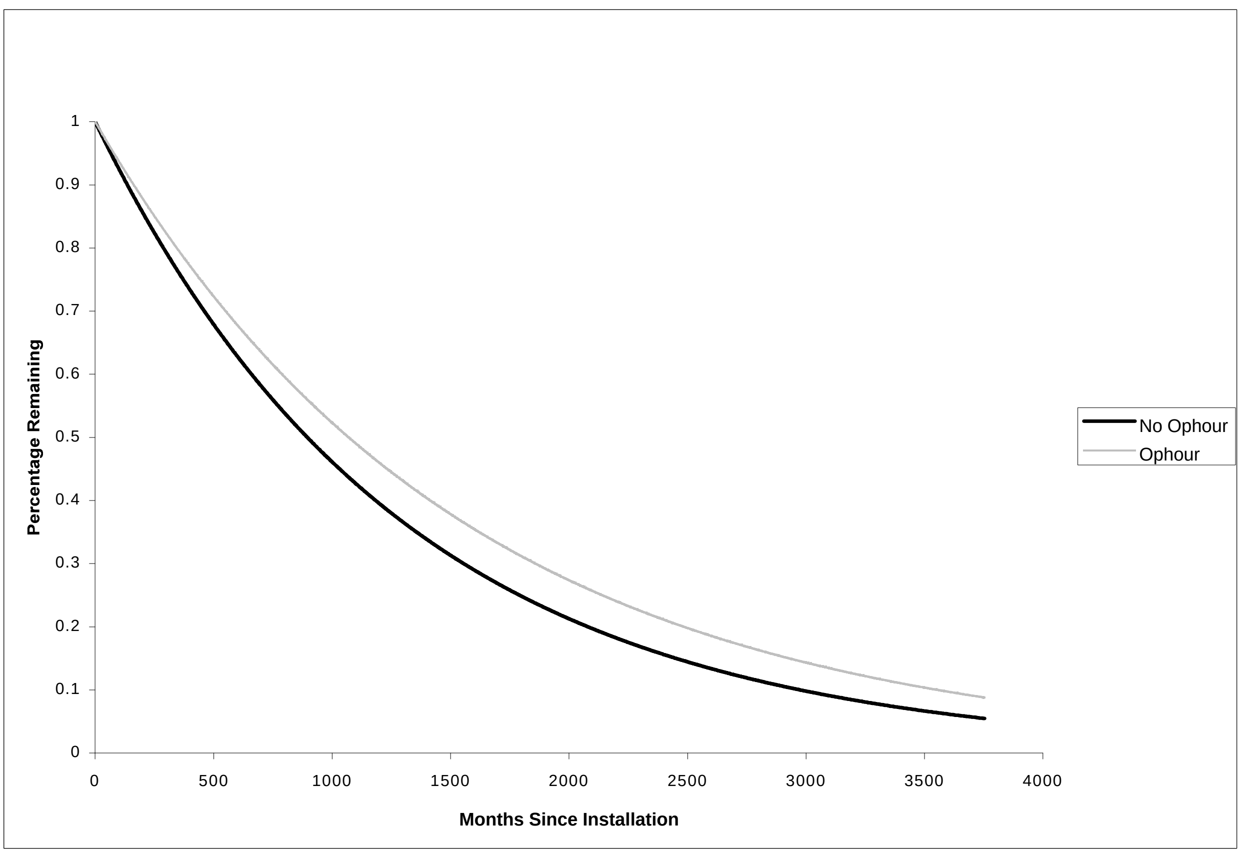
Some of the same issues we faced when developing the empirical survival function need to be addressed here as well. The problem of right-hand censoring is not an issue for SAS. The LIFEREG procedure, which we used for all of our modeling in this step, is capable of handling right-hand censored data.

SAS is also capable of handling left-hand censored data. In fact, our retention data is actually not left-hand censored, but interval censored. The true definition of left-hand censoring is that we know that an event occurred earlier than some time t, but we don’t know exactly when. Interval censoring occurs when the time of failure occurrence is known to be somewhere between two times, but we don’t know exactly when. Left censoring can be seen as a special case of interval censoring.

Although the LIFEREG procedure is capable of handling both left and interval censoring, interval censored data is more predictive than left hand censoring. Another commonly used survival analysis procedure in SAS in PHREG. Unfortunately, this procedure cannot handle either left or interval censored data. Therefore, we only conducted our analysis using the LIFEREG procedure.

Another important feature of the LIFEREG procedure is the use of covariates. This feature enabled us to use other predictive variables to help estimate the survival functions. For example, it would be expected that the EUL for a T8 is dependent on the number of hours that it is used during a year. So, an obvious covariate would be the inclusion of operating hours for each of our customers in the retention sample. Exhibit 3-32 compares the estimated survival function for the L23 T8 measure using the LIFEREG procedure without covariates, and with operating hours as a covariate. Here, we are using modeling the survival function with an exponential distribution.

Exhibit 3-32
Comparison of Survival Functions
Modeled without Covariates and with Operating Hours as a Covariate
L23 T8 Measure



The two survival functions are relatively similar, with the model using operating hours as a covariate resulting in an EUL. The parameter estimate on operating hours is negative, as expected, indicating that the more hours in operation, the more likely a failure will occur. We decided to use the model that incorporates operating hours as a covariate, because it adds more information to the model. Only the L23 T8 and L81 HID 251-400W measures had a sufficient sample size to utilize operating hours. For the L37 HID >=176W and S22 ASD measures, the sample was focused on a single business type, not providing sufficient variation among operating hours across customers. Therefore, the L37 HID >=176W and S22 ASD measures did not use any covariates.

As discussed above, the LIFEREG procedure was used to model the survival function for the L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD measures. Exhibit 3-33 compares the exponential survival function versus the exponential trendline that was estimated based on the empirical survival function discussed above. We can see how similar the estimated survival function is for these two approaches.

Exhibit 3-33
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline
L23 T8 Measure

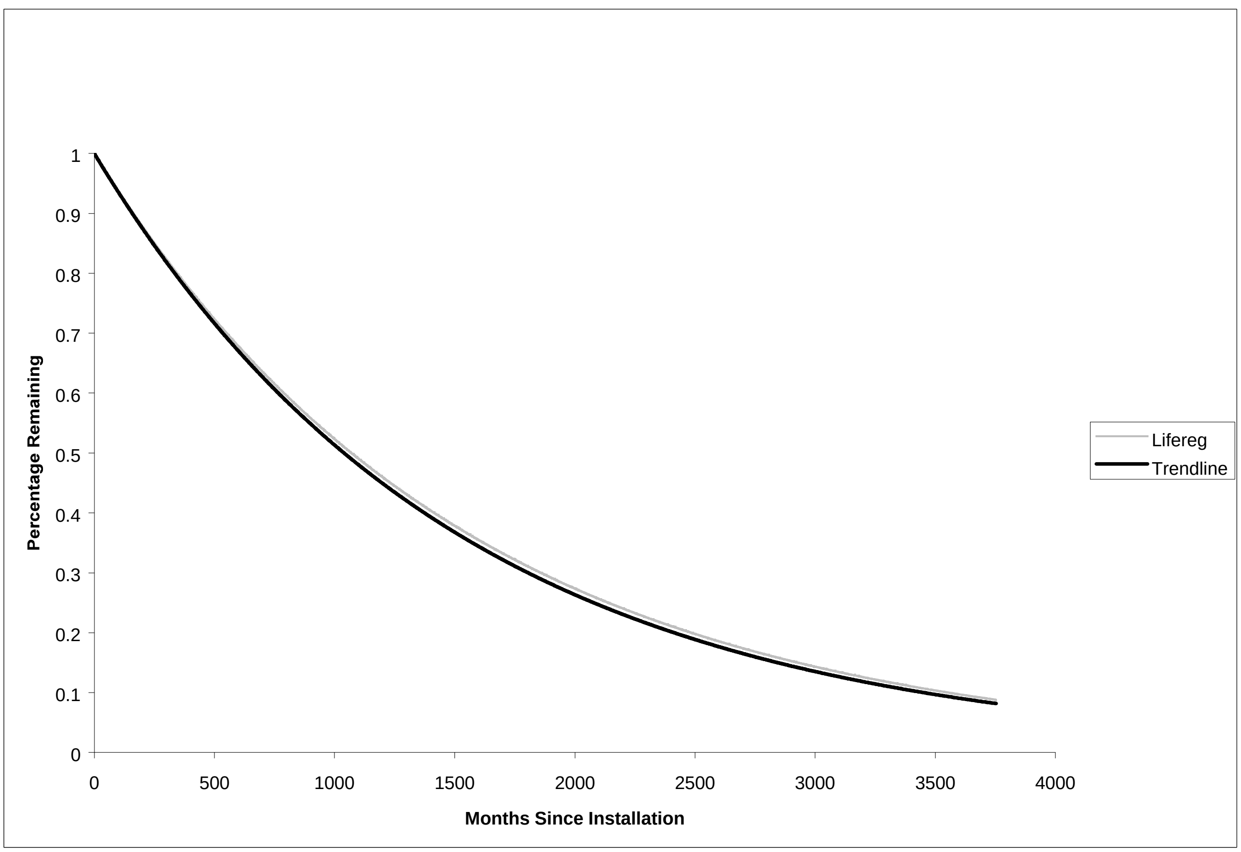


Exhibit 3-34 compares the empirical survival function, with both the LIFEREG estimate of the exponential survival function and the exponential trendline, over the first 40 months of the measure's life.

Exhibit 3-34
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline versus Empirical Function
L23 T8 Measure

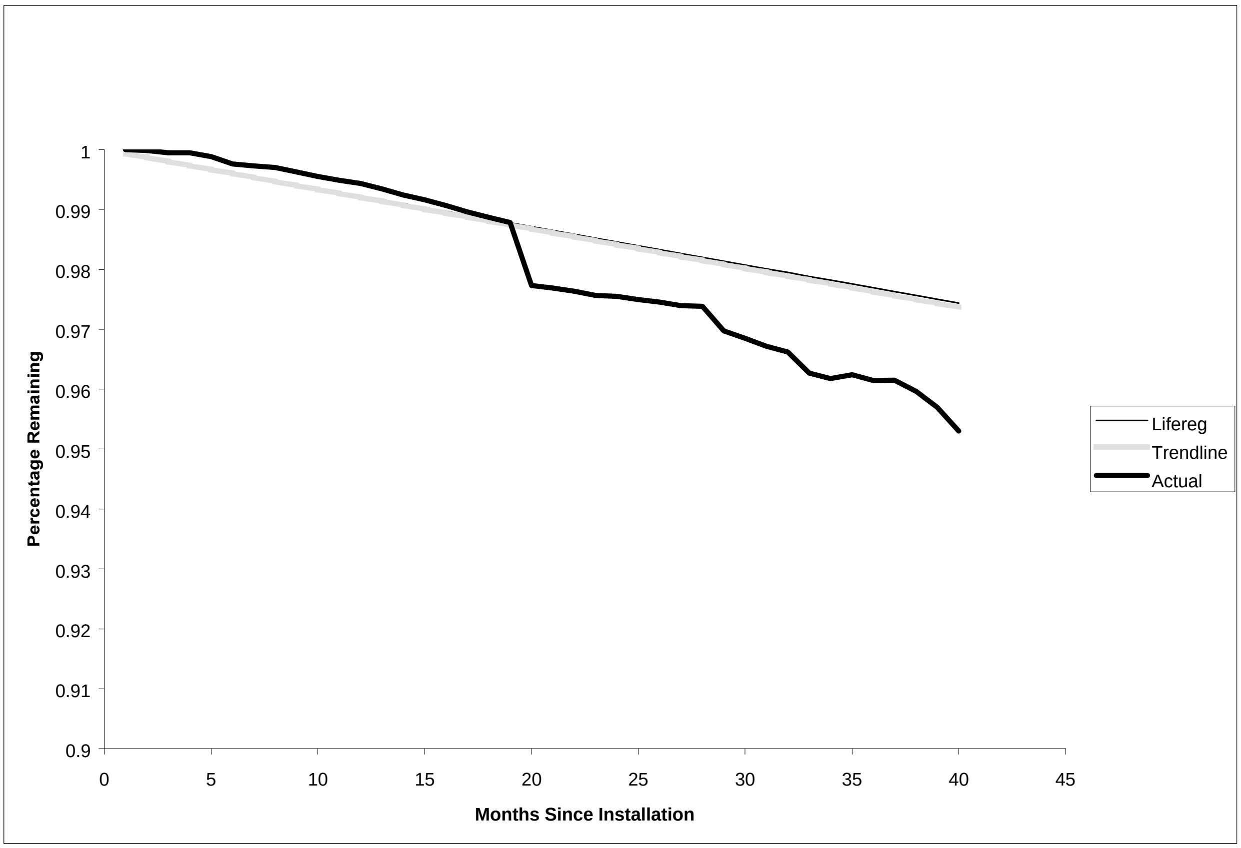


Exhibit 3-35 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the L23 T8 measure using the LIFEREG procedure. Exhibit 3-36 compares these five survival functions with the empirical survival function, over the first 40 months of the measure's life.

Exhibit 3-35
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
L23 T8 Measure

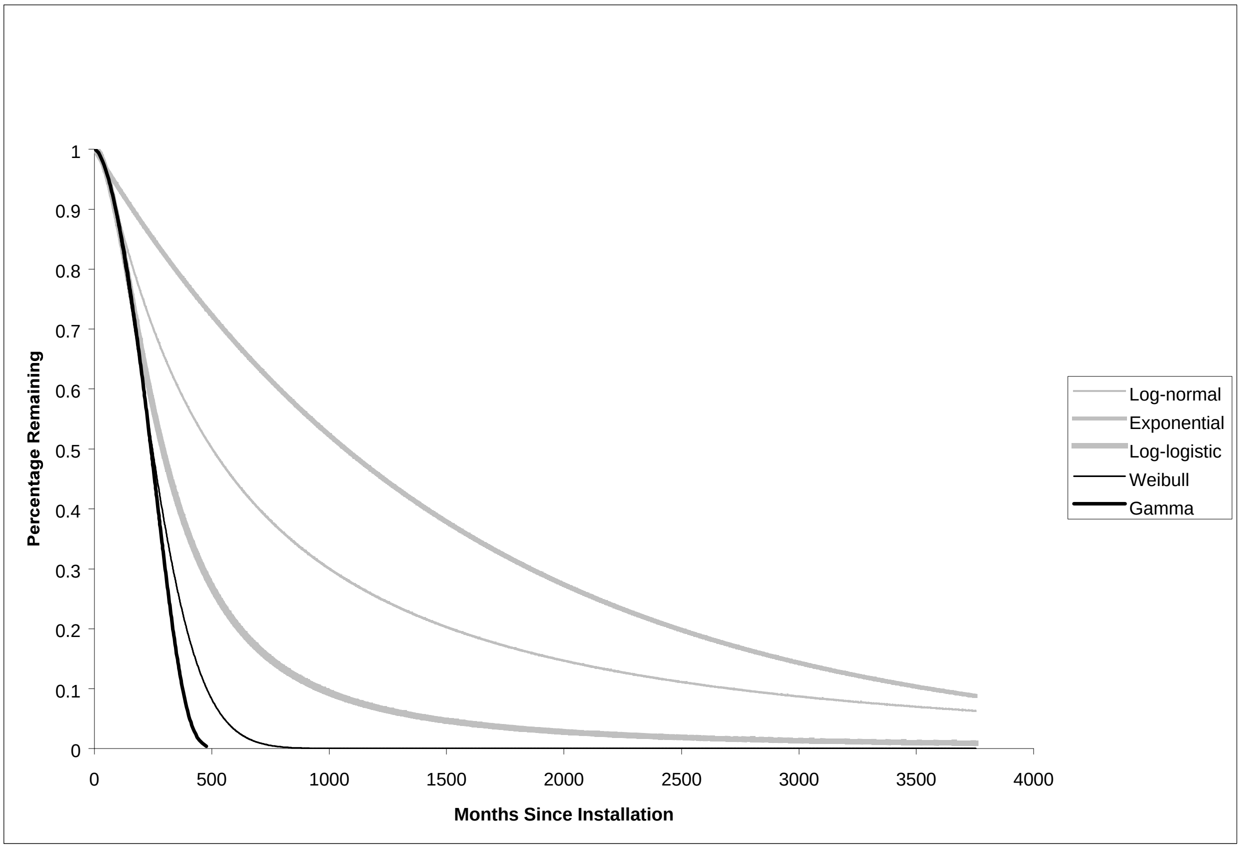


Exhibit 3-36
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
L23 T8 Measure

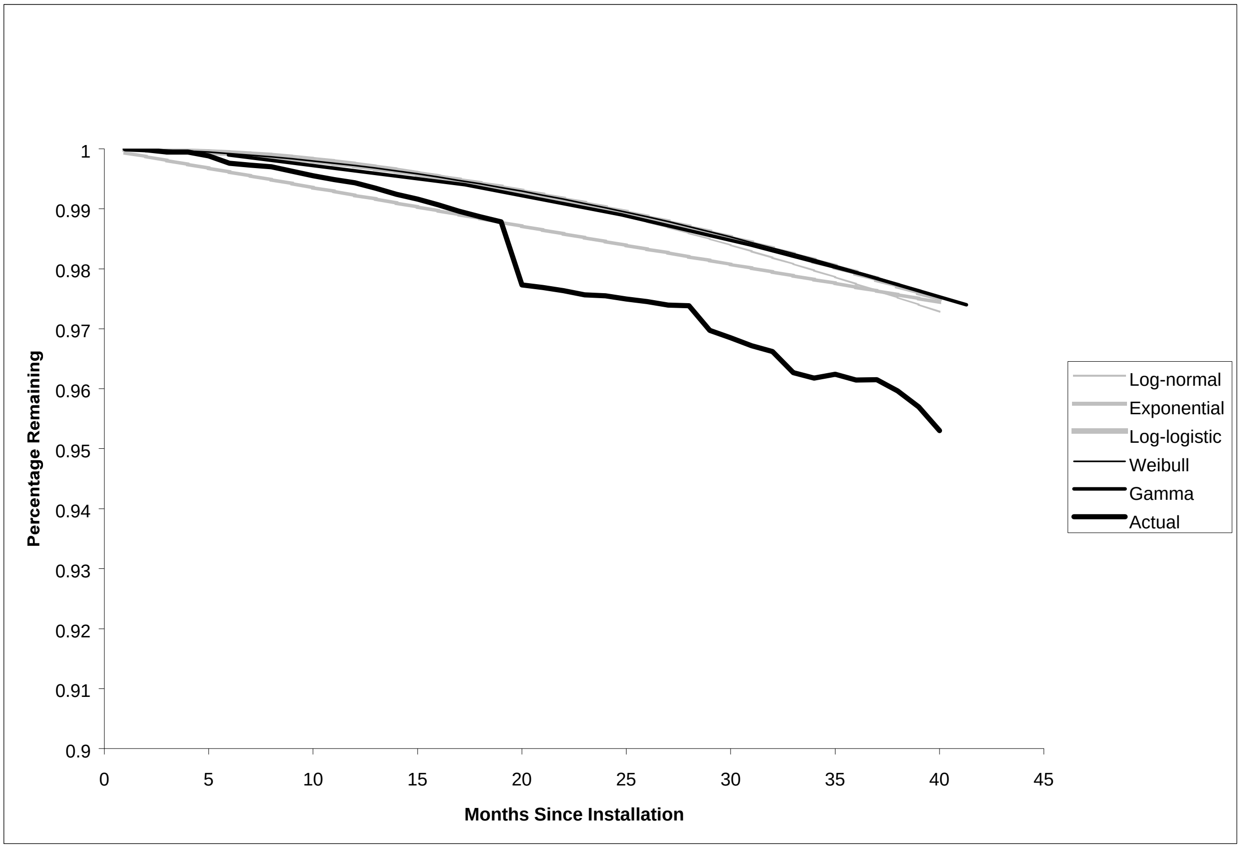


Exhibit 3-37 provides the estimated exponential survival function for the L37 HID >=176W measure, and compares it with exponential trendline that was estimated based on the empirical survival function discussed above. Exhibit 3-38 compares the empirical survival function, with both the LIFEREG estimate of the exponential survival function and the exponential trendline, over the first 55 months of the measure's life.

Exhibit 3-37
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline
L37 HID >=176W Measure

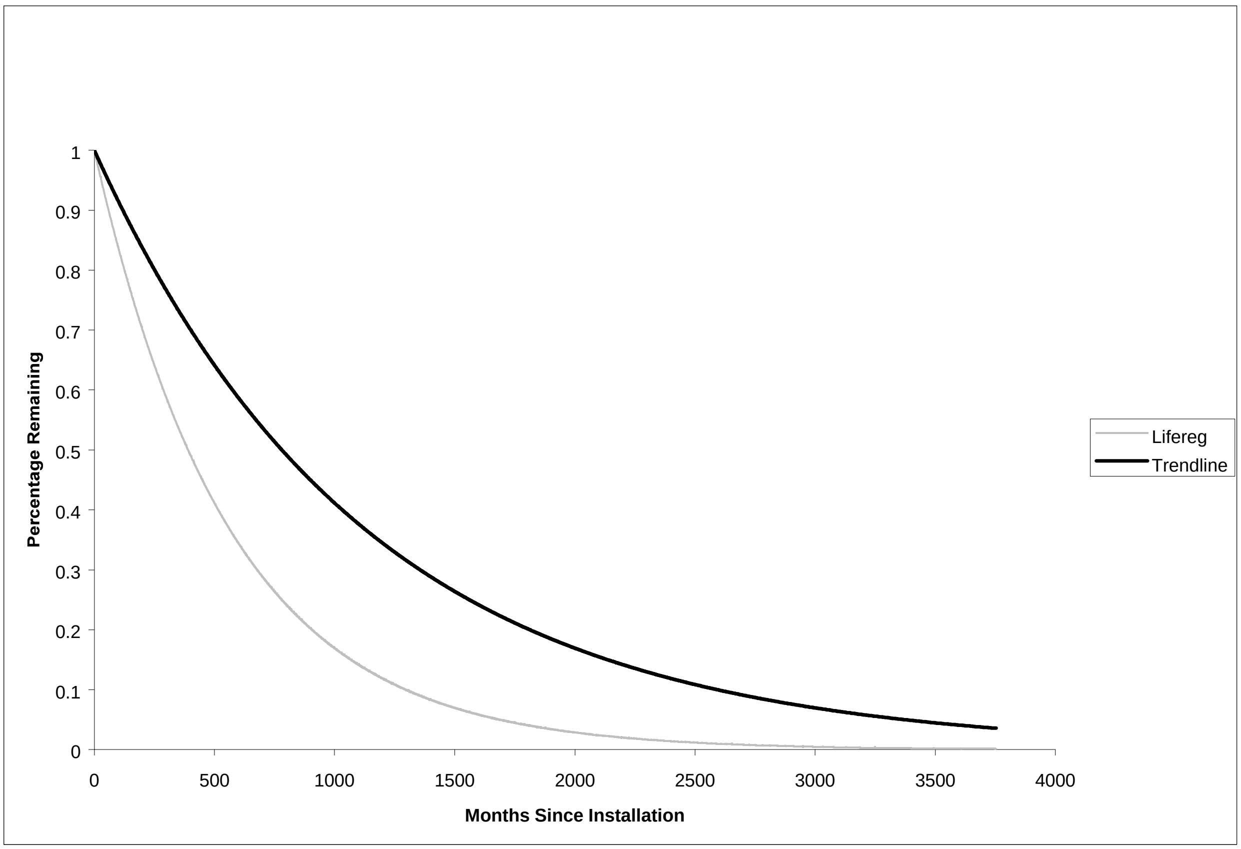


Exhibit 3-38
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline versus Empirical Function
L37 HID >=176W Measure

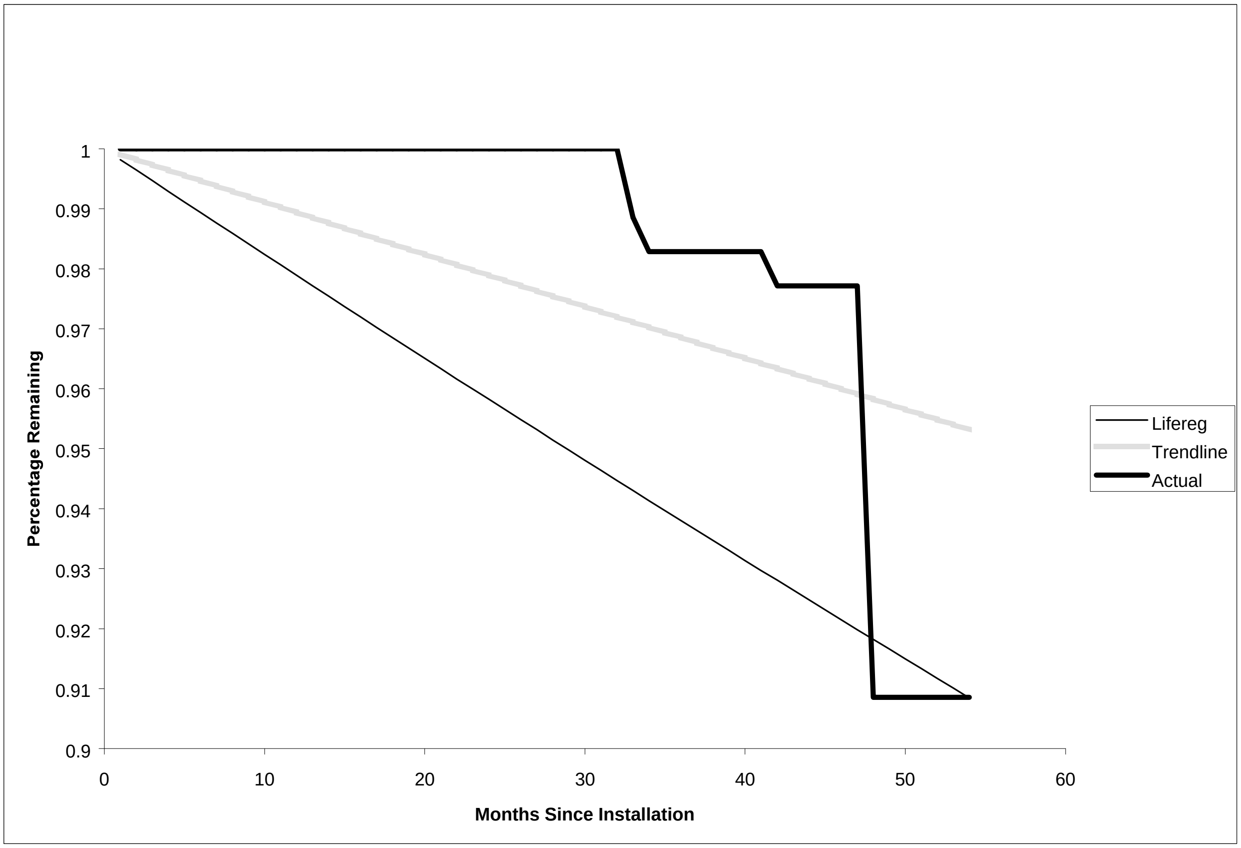


Exhibit 3-39 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the L37 HID >=176W measure using the LIFEREG procedure. Exhibit 3-40 compares these five survival functions with the empirical survival function, over the first 55 months of the measure's life.

Exhibit 3-39
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
L37 HID >=176W Measure

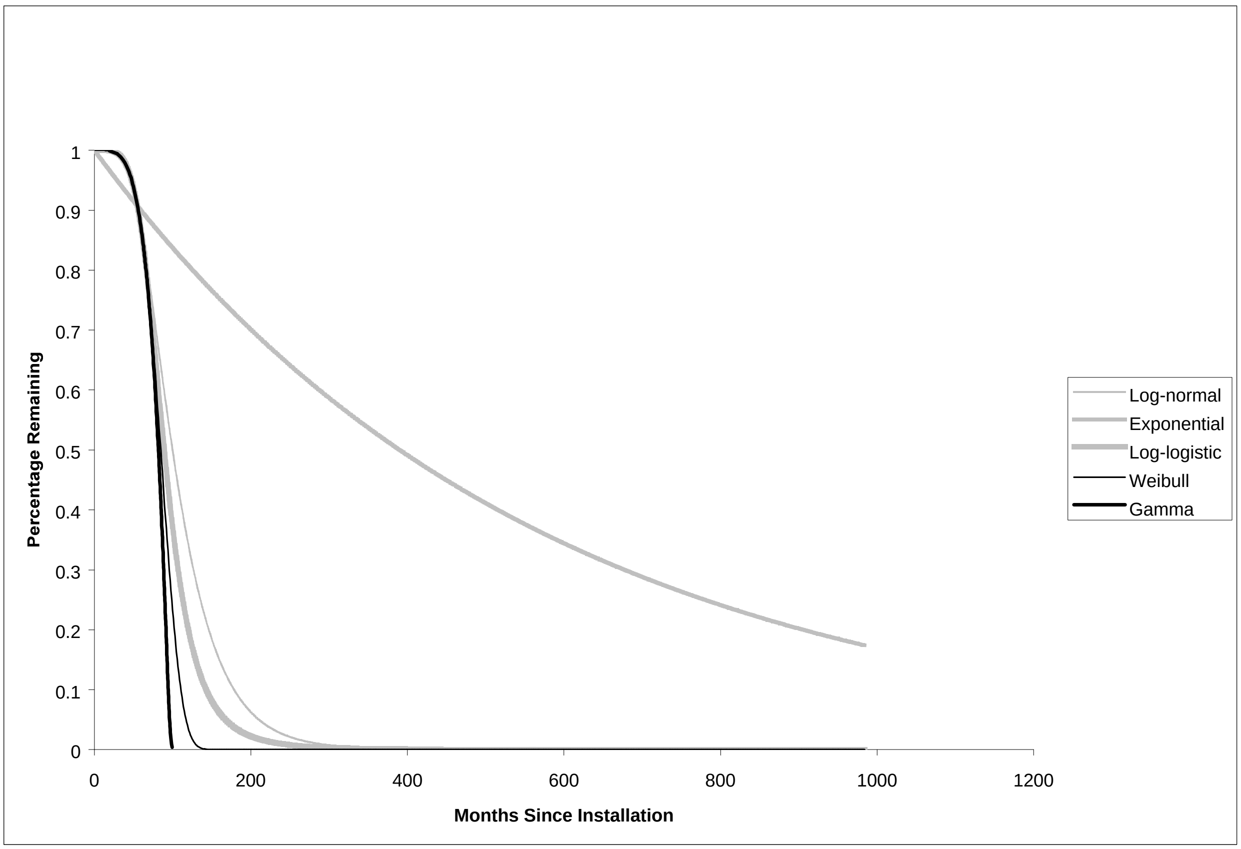
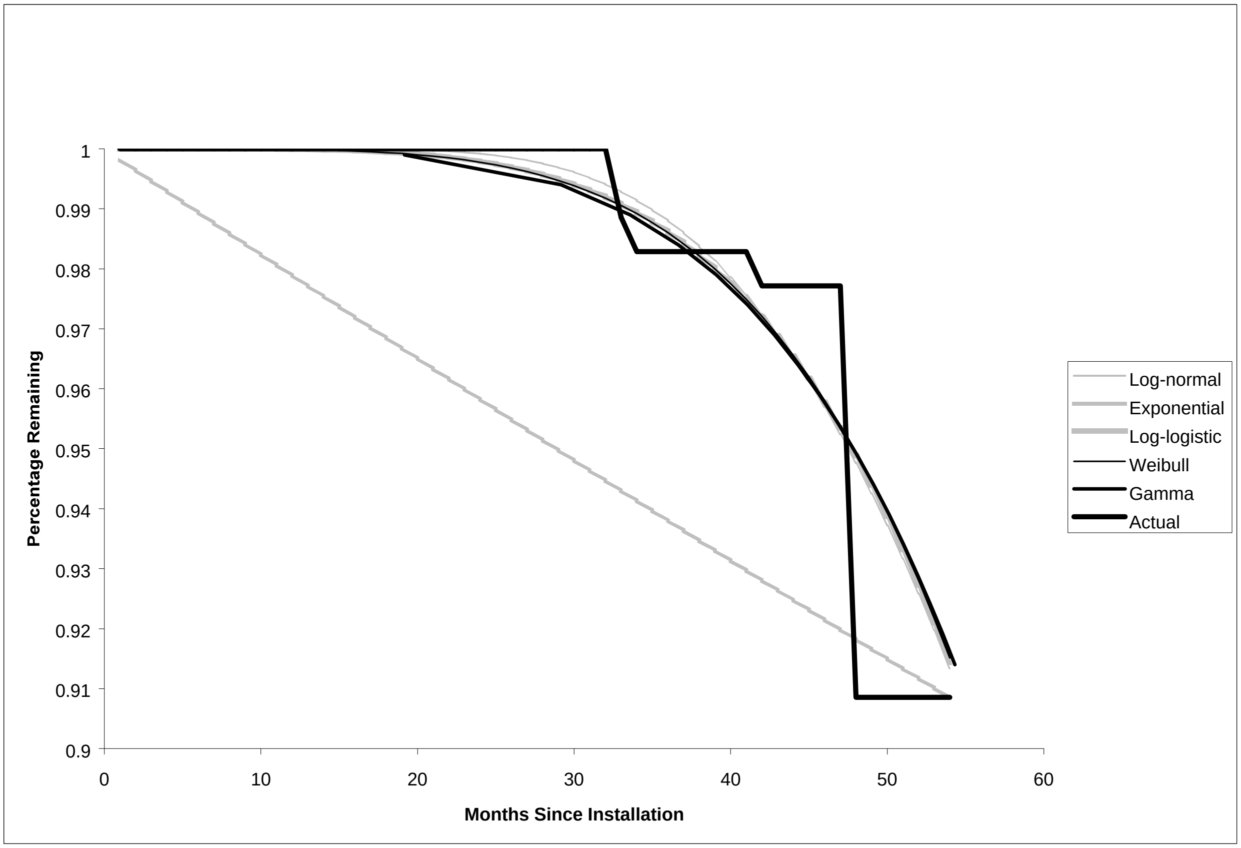


Exhibit 3-40
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
L37 HID >=176W Measure

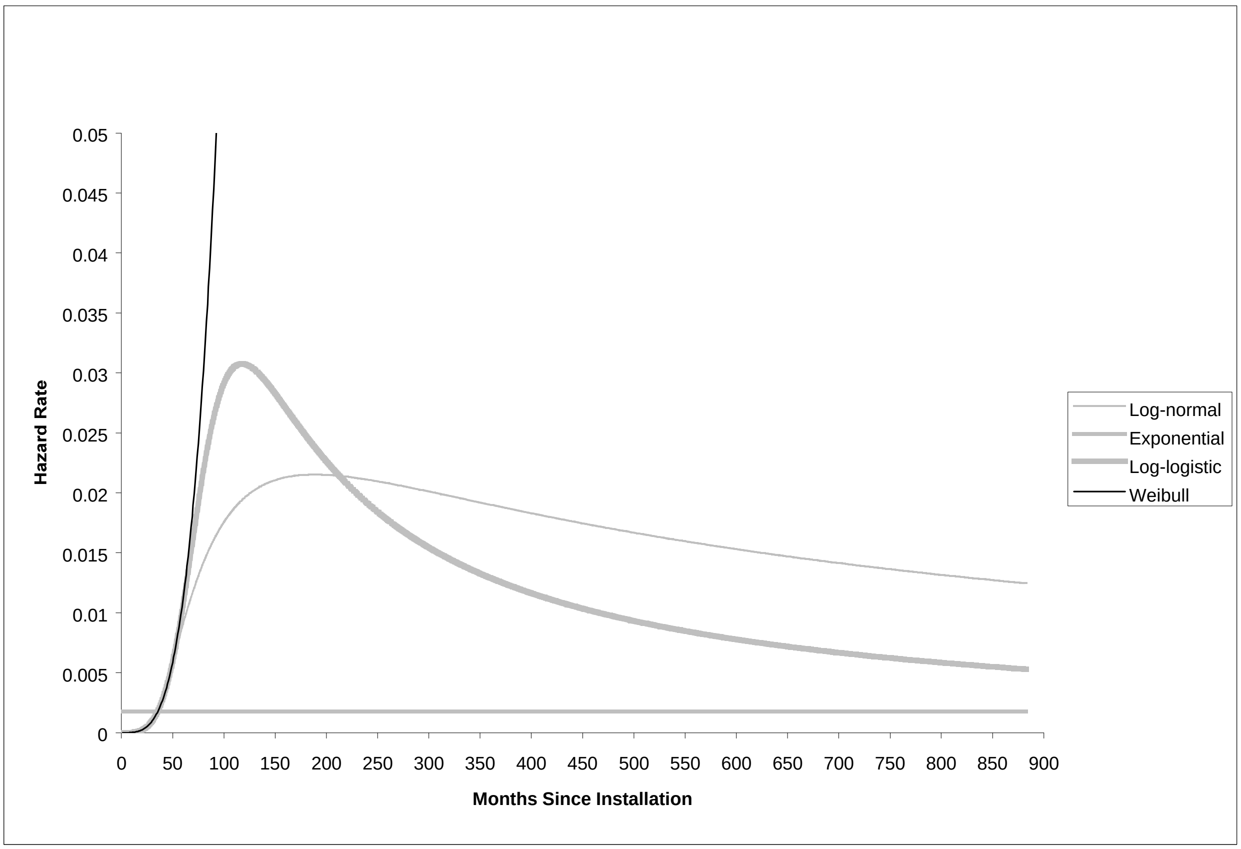


As discussed earlier, one of the 17 customers included in the L37 HID >=176W sample removed all 12 of their HIDs during month 48. Because of the small sample size for the L37 HID >=176W measure (only 17 customers and 175 units), this customer's removal had a significant effect on the model results. We already discussed the effect this customer had on the trendline analysis, which caused the median EUL estimate to be cut roughly in half. The effects on the LIFEREG procedures are similar, and in some cases more significant.

Recall that the exponential distribution has a constant hazard rate, such that the percentage of failures/removals among the currently operable equipment is fixed over time. The logistic, log-normal, Weibull and gamma distributions, however, generally are associated with an *increasing* hazard rate over the early life of the measure. When we inspect the empirical survival function for the L37 HID >=176W measure, we see that no failures have occurred over the first 32 months of installation. Then, over the next 15 months, only 2.3 percent of the measures have failed or been removed. Finally, over the next few months, 7 percent of the operable measures failed or were removed. The LIFEREG procedure takes this to be an indication of a very rapidly increasing hazard rate, and models the logistic, log-normal, Weibull and gamma distributions as such.

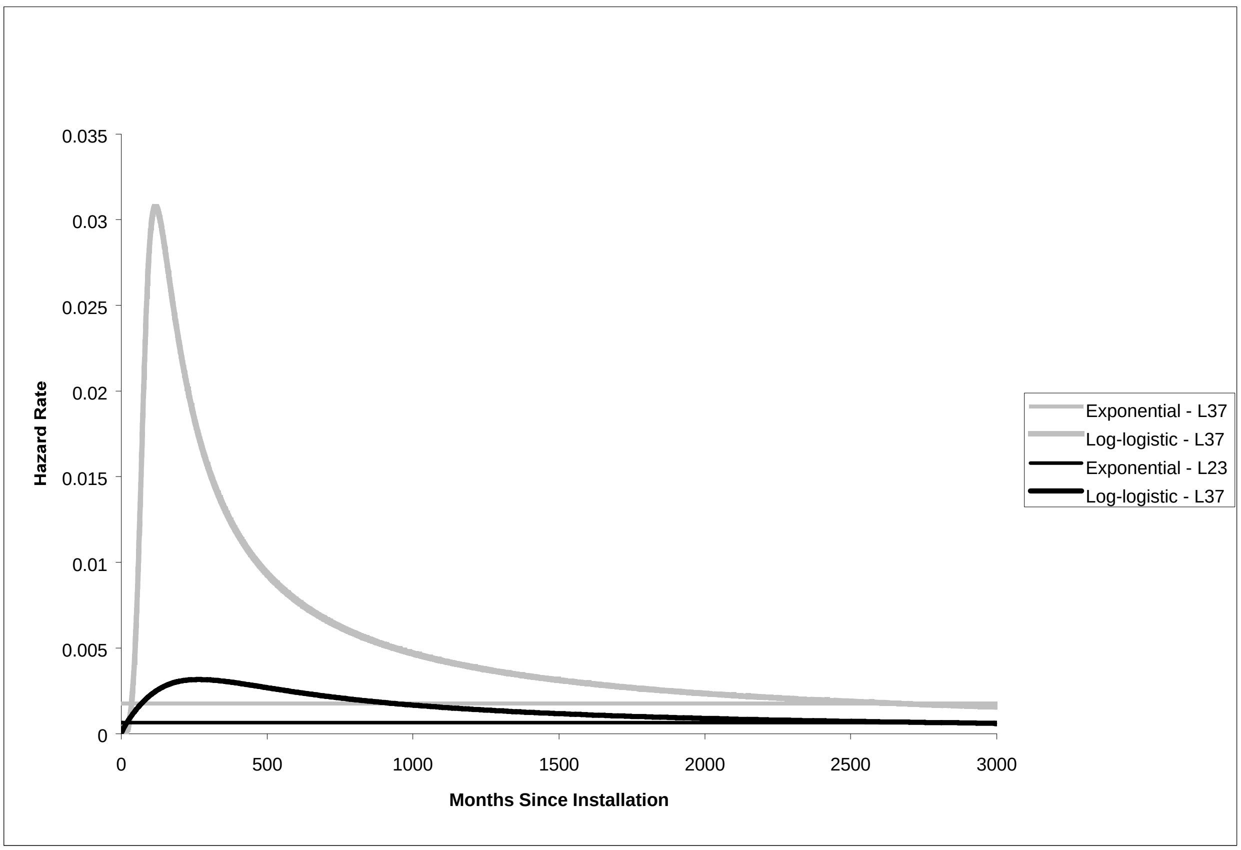
Exhibit 3-41 provides the hazard functions for the exponential, logistic, log-normal, and Weibull distributions. As discussed, the exponential distribution exhibits a constant hazard rate. The logistic and log-normal distributions have increasing hazard rates over the early portion of the measure's life, peaking near the median life, and decreasing for the remainder of the life. The Weibull decreases at an incredible rate, off the scale of the chart. The gamma distribution is not shown, due to difficulty in estimating the hazard rate from SAS for this distribution.

Exhibit 3-41
Comparison of Hazard Rates
Exponential, Logistic, Lognormal, and Weibull Functions
L37 HID >=176W Measure



The hazard rate for the logistic, log-normal, and Weibull distributions are exceptionally steep relative to the exponential distribution. At times, the hazard rates are more than 10 times that of the exponential distribution. In addition, the hazard rate of the L37 HID >=176W measures relative to the L23 T8 measure is also exceptionally steep. Exhibit 3-42 compares the hazard rates for the L23 T8 and L37 HID >=176W measures, for both the exponential and logistic distributions. For the exponential distributions, the L37 HID >=176W measure's hazard rate is only a few times larger than the L23 T8 rate. For the logistic distribution, however, the L37 HID >=176W measure's hazard rate is more than 10 times larger than the L23 T8 rate.

Exhibit 3-42
Comparison of Hazard Rates
Exponential and Logistic Functions
L23 T8 versus L37 HID >=176W Measure



As seen in Exhibit 3-40, the modeled distributions for the L37 HID >=176W measure fit the empirical distribution quite well. The concern, however, is whether or not it is realistic to assume that the true distribution will continue to drop at such an alarming rate as shown in Exhibit 3-39. Recall our earlier discussion on how the EUL is dependent on two components: failures and removals. Where failures may follow a smooth distribution, it is likely that removals will follow more of a step-wise distribution, as removals occur in lots; whereas failures generally occur one at a time.

We can analyze the influence of this one customer on our models by removing the customer from the analysis and re-estimating the five survival functions. Exhibit 3-43 provides the results of the LIFEREG procedure after removing this one customer. Exhibit 3-44 plots these five revised survival functions against the empirical distribution (which includes the one customer).

Exhibit 3-43
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
After Removal of One Influential Customer
L37 HID >=176W Measure

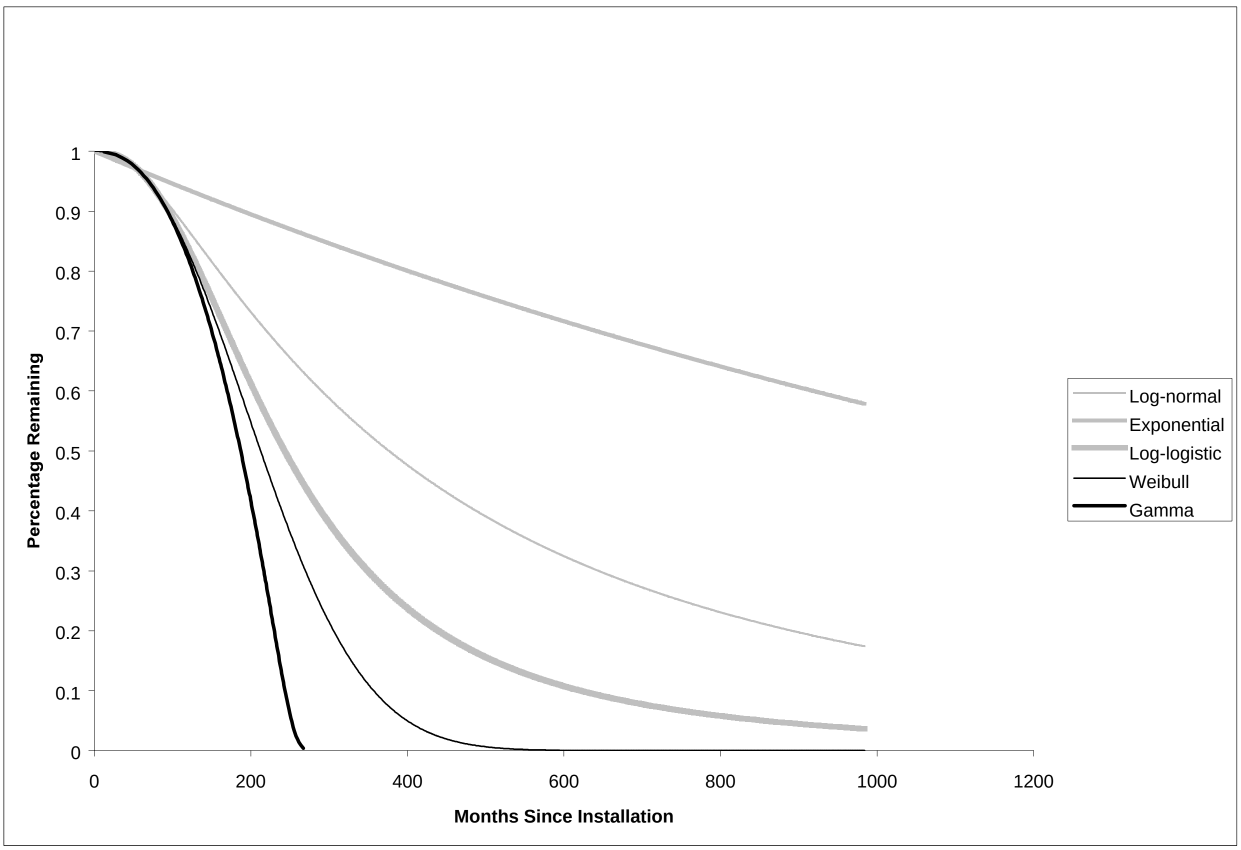
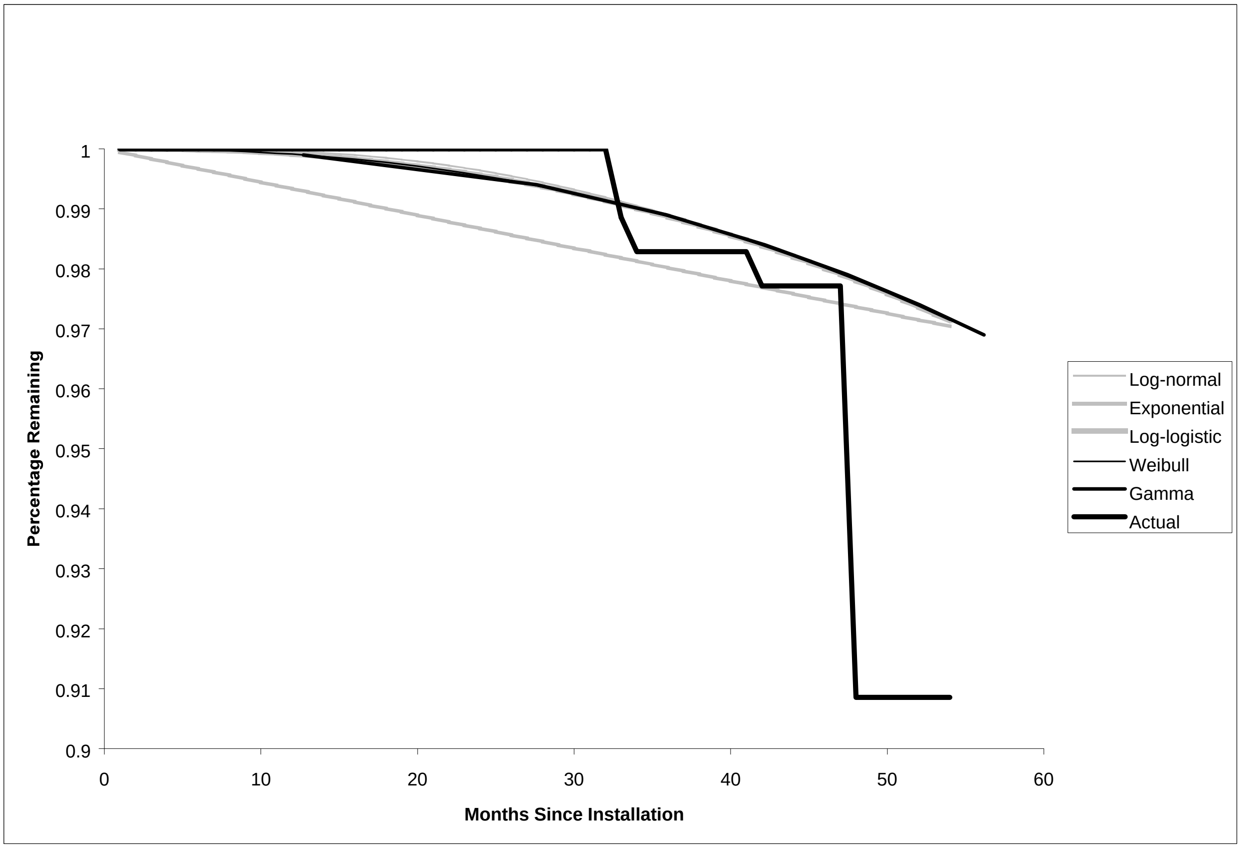


Exhibit 3-44
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
After Removal of One Influential Customer
L37 HID >=176W Measure



Perhaps a more interesting exercise is a direct comparison between one of the survival distributions, say logistic, plotted both with and without the one customer, as shown in Exhibit 3-45. Here, we see how steep the slope of the survival function is with the inclusion of the one customer.

Exhibit 3-45
Comparison of Logistic Survival Functions
With and Without One Influential Customer
L37 HID >=176W Measure

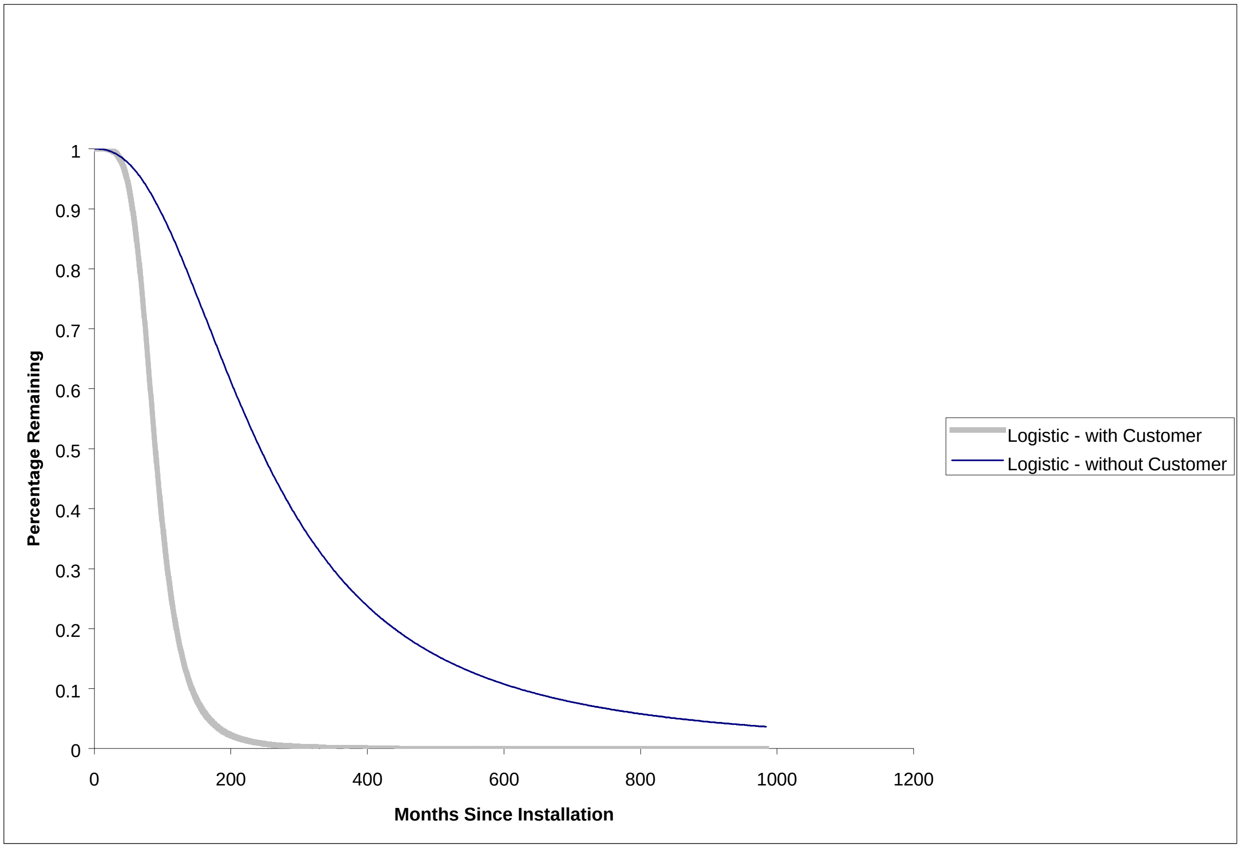
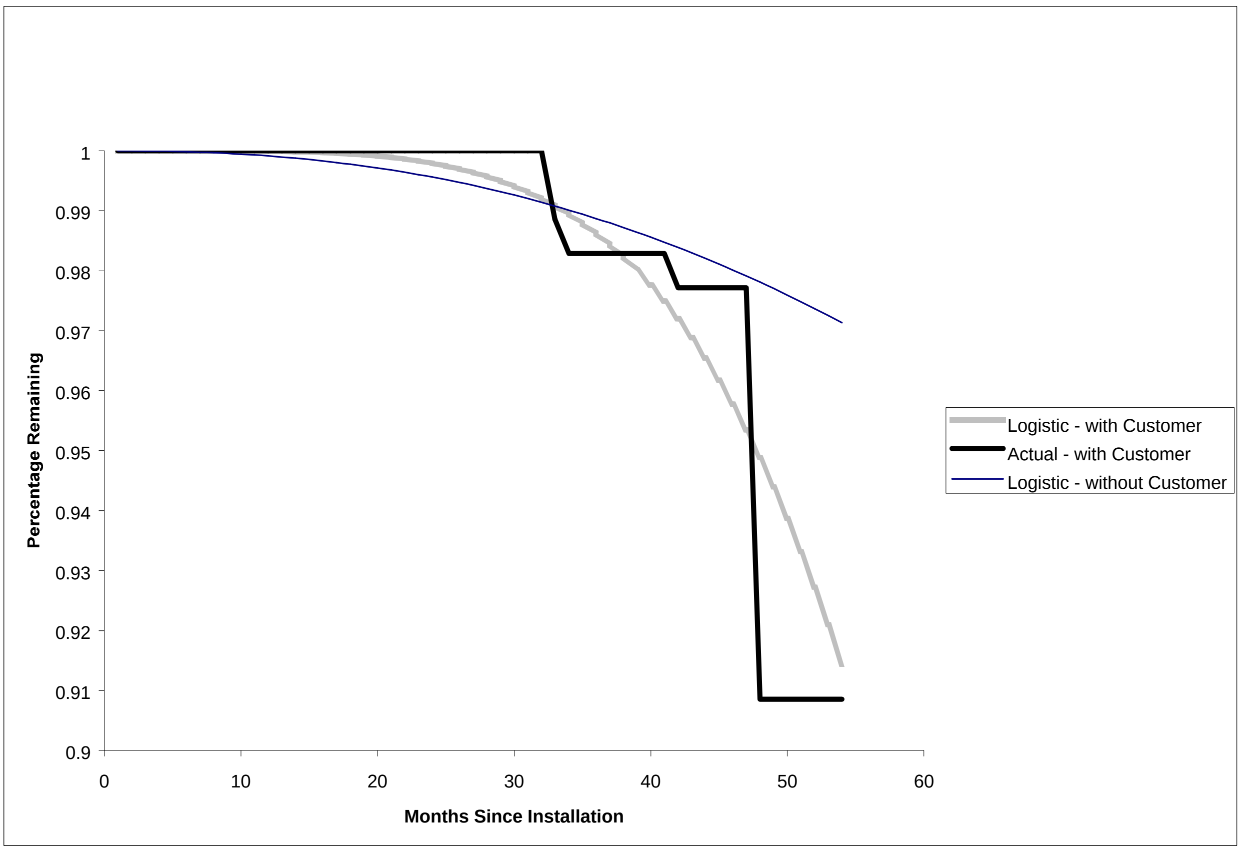


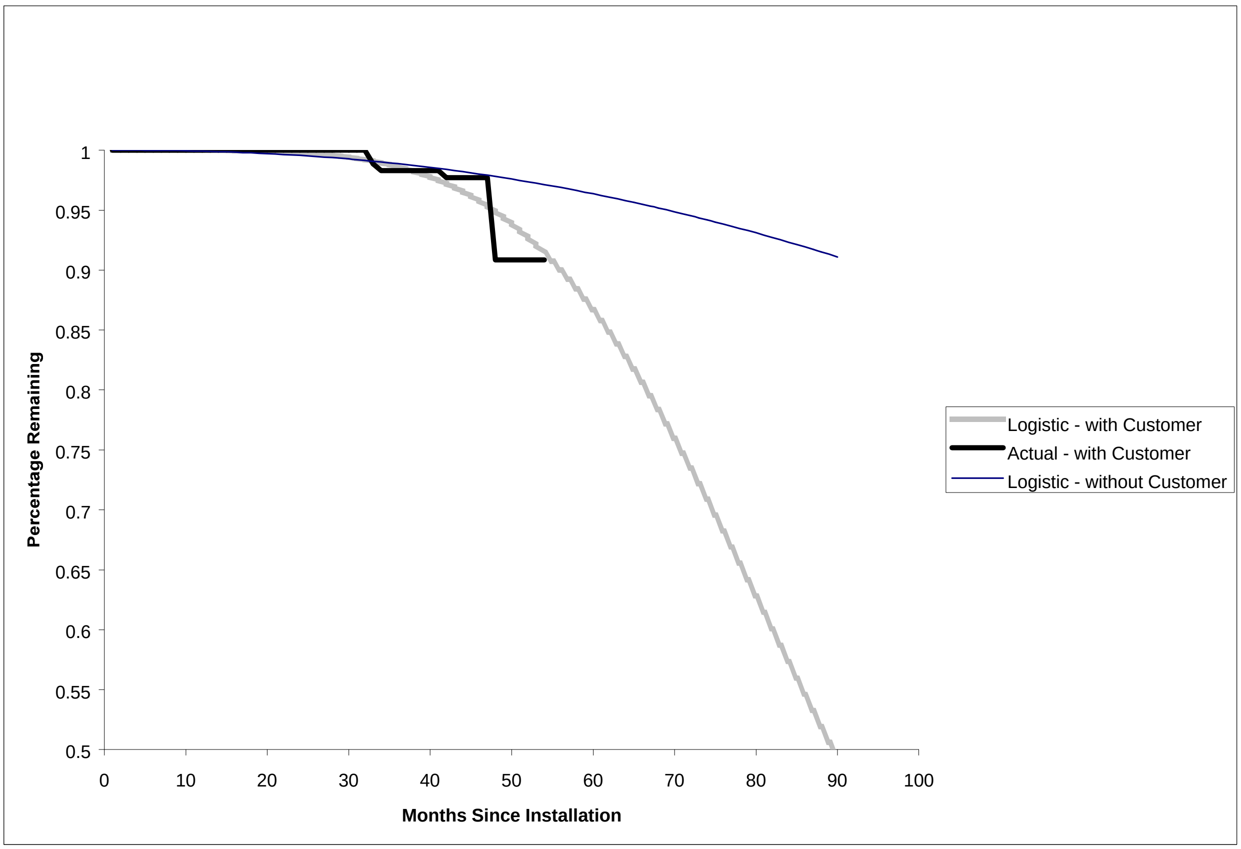
Exhibit 3-46 plots the two logistic survival functions, with and without the one influential customer, versus the empirical survival function, with the influential customer. Here we see that the shape of the logistic survival function with the influential customer is being driven by the removal that occurred in month 48.

Exhibit 3-46
Comparison of Logistic Survival Functions versus Empirical Function
With and Without One Influential Customer
L37 HID >=176W Measure



Because we are using these functions to estimate the EUL, it is interesting to extend the plot above to the time when the survival function with the influential customer reaches the median point. Exhibit 3-47 extends the same graph from Exhibit 3-46 to 90 months, just three years later than the Exhibit 3-46. In this time frame, the survival function with the influential customer predicts that the percentage of operable equipment will fall from 91 to 49 percent! In comparison, the survival function without the influential customer predicts that the percentage of operable equipment will fall from 97 to 91 percent.

Exhibit 3-47
Comparison of Logistic Survival Functions versus Empirical Function
With and Without One Influential Customer
First 90 Months
L37 HID >=176W Measure



Clearly, this one customer exerts significant influence over the model results. Leaving the customer in appears to significantly underestimate the EUL; whereas removing the customer would likely overestimate the EUL. To resolve this issue, we decided to group the L81 HID 251-400W and L37 HID >=176W measures together. Both measures are grouped with the same set of like measures, have the same ex ante EUL, and should be expected to have very similar survival functions.

Below, we will first provide the results of the L81 HID 251-400W measure, on its own, and then present the results of the combined L37 and L81 HID models. Exhibit 3-48 provides the estimated exponential survival function for the L81 HID 251-400W measure, and compares it with exponential trendline that was estimated based on the empirical survival function discussed above. Exhibit 3-49 compares the empirical survival function, with both the LIFEREG estimate of the exponential survival function and the exponential trendline, over the first 40 months of the measure's life.

Exhibit 3-48
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline
L81 HID 251-400W Measure

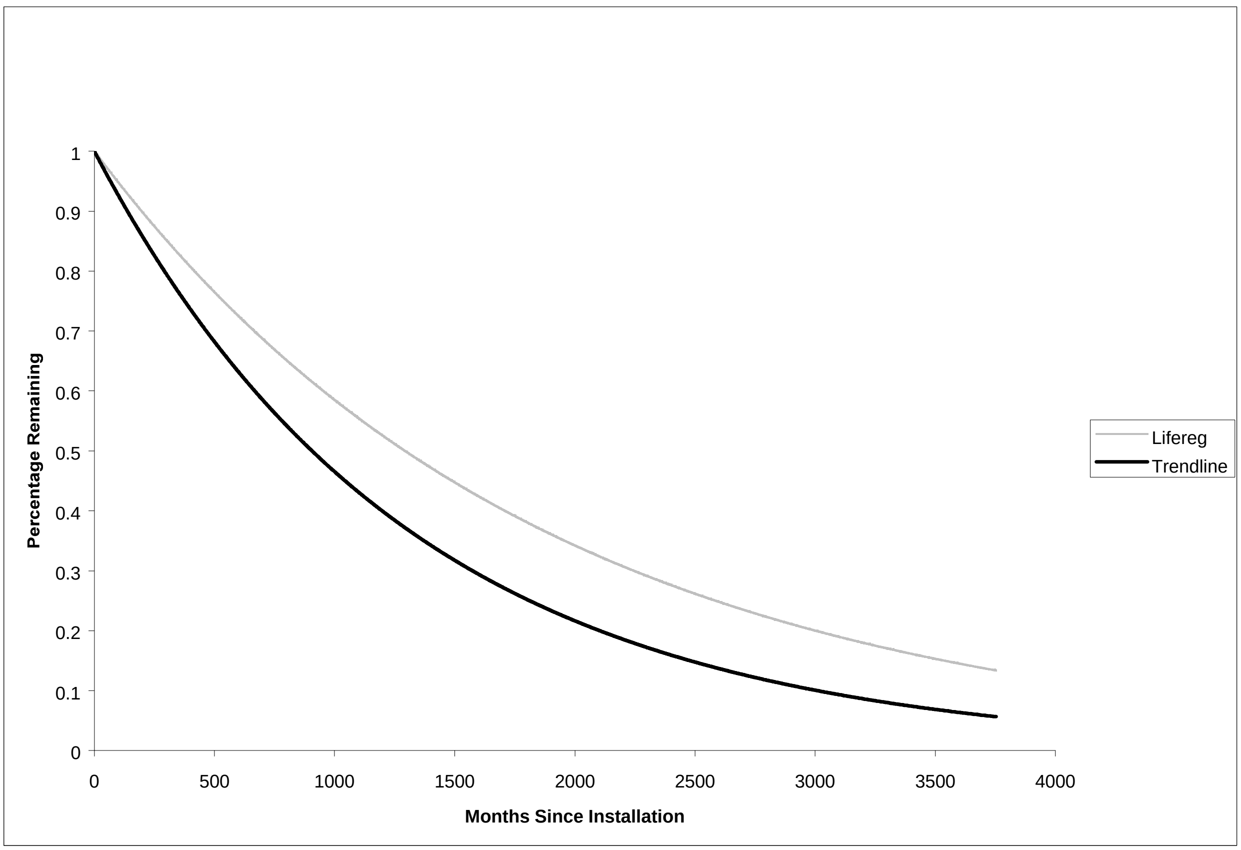


Exhibit 3-49
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline versus Empirical Function
L81 HID 251-400W Measure

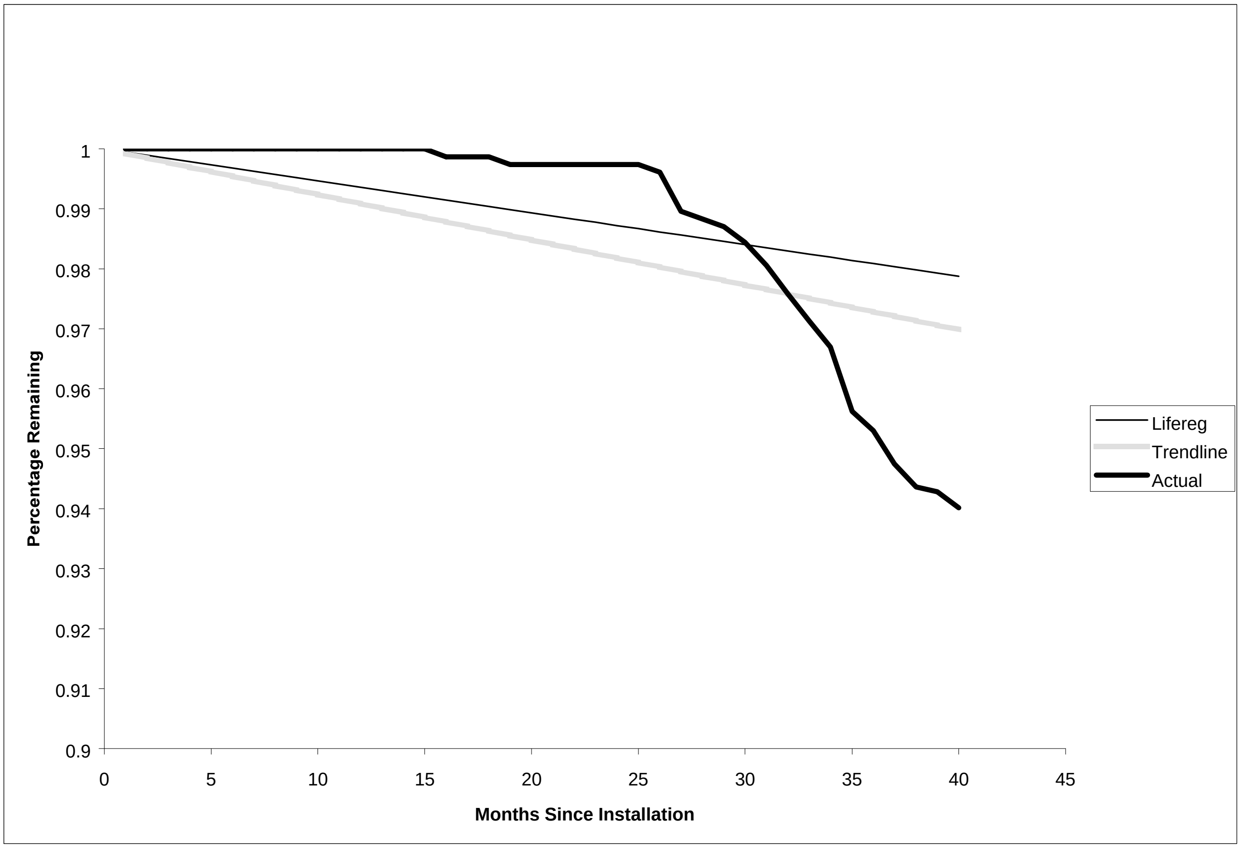


Exhibit 3-50 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the L81 HID 251-400W measure using the LIFEREG procedure. Exhibit 3-51 compares these five survival functions with the empirical survival function, over the first 40 months of the measure's life.

Exhibit 3-50
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
L81 HID 251-400W Measure

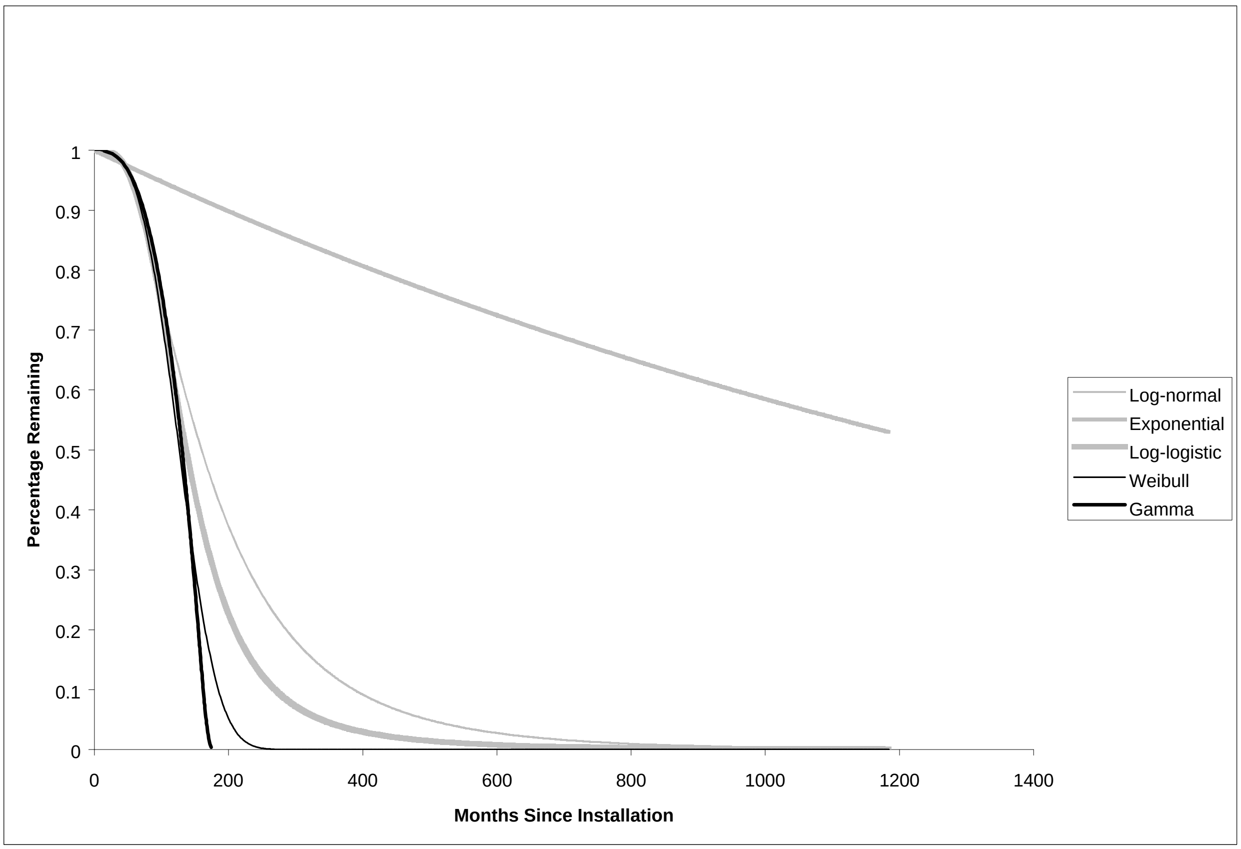
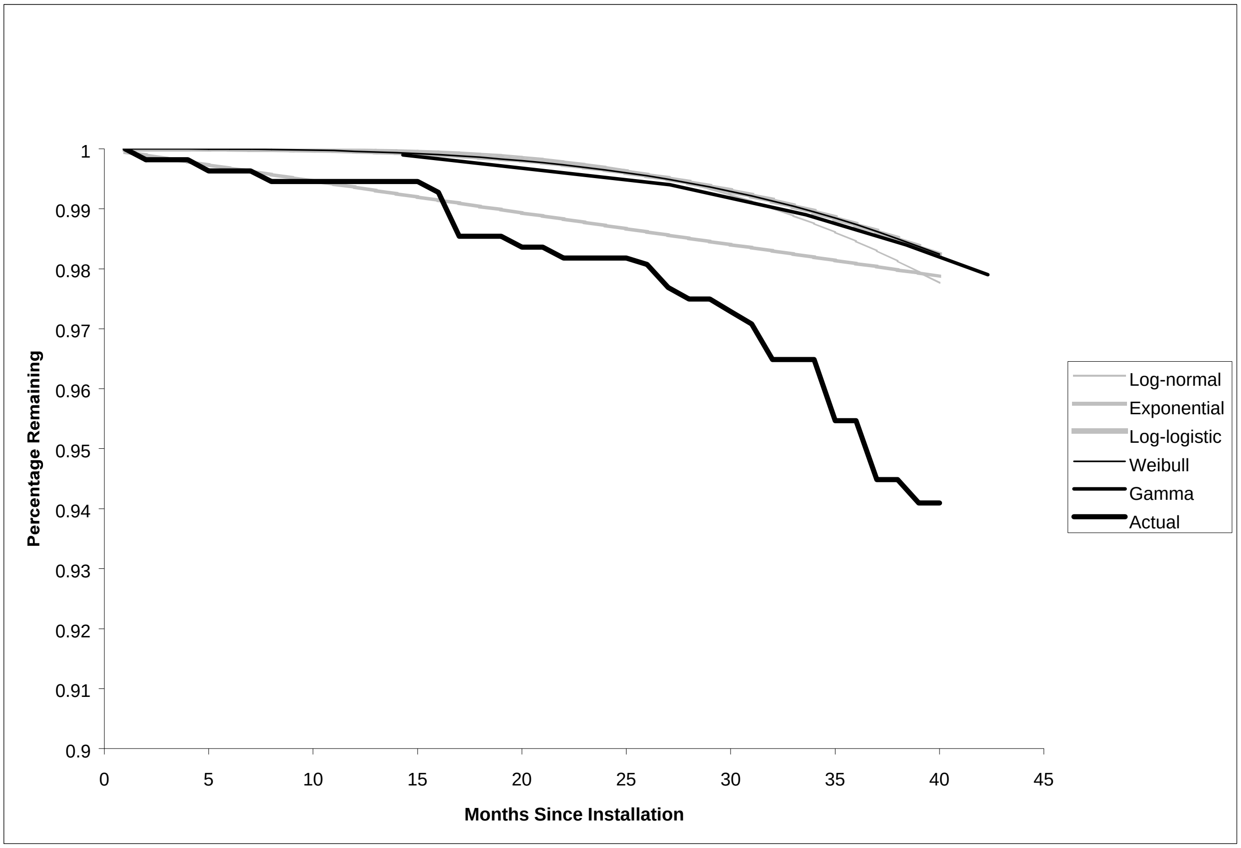


Exhibit 3-51
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
L81 HID 251-400W Measure



As discussed above, we have also run the LIFEREG models and combined the L37 HID >=176W and L81 HID 251-400W measures. Exhibit 3-52 compares the empirical survival function for the combined measures, versus the individual measures over the first 48 months. Because of limited L81 HID 251-400W sample beyond 48 months, only these months are shown.

Exhibit 3-52
Comparison of Empirical Survival Functions
L37 HID >=176W, L81 HID 251-400W and Combined Measures

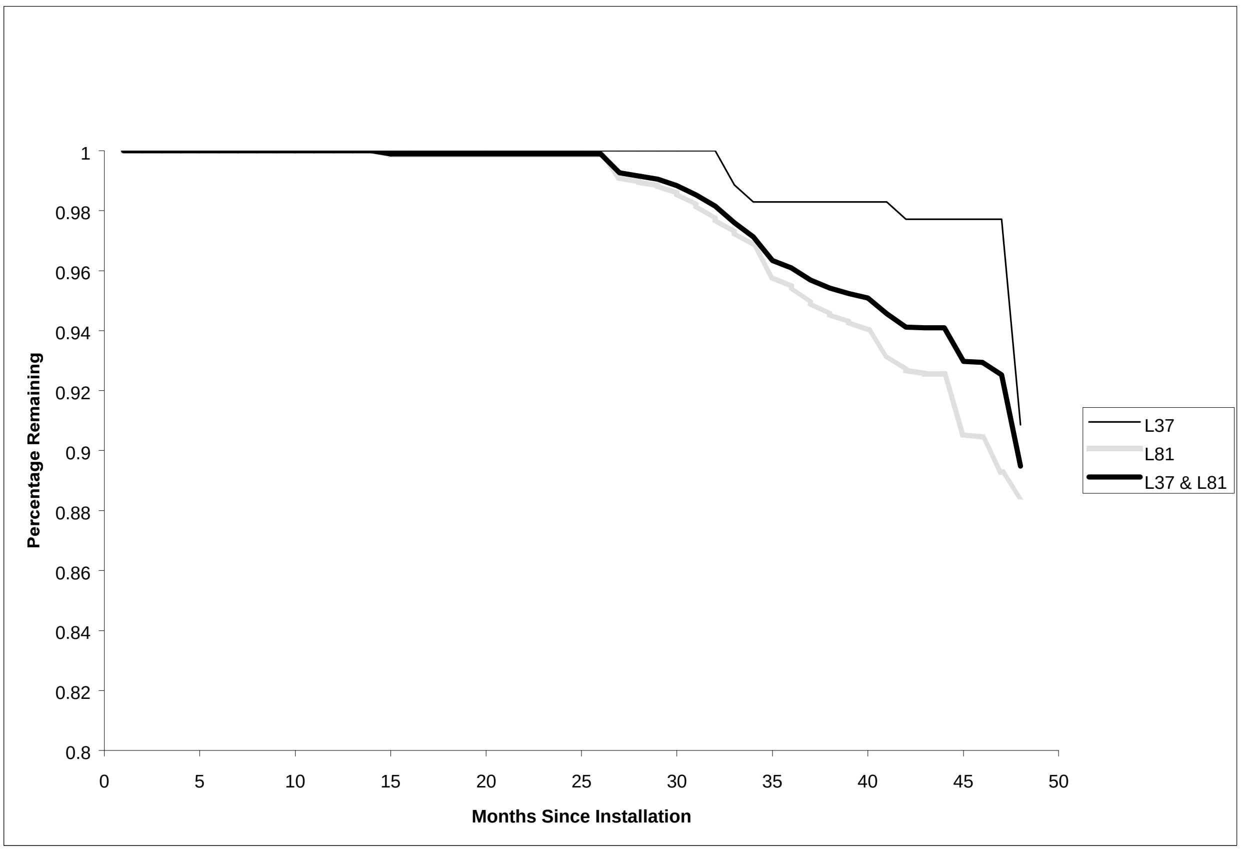


Exhibit 3-53 compares the logistic model results for the combined measures, versus the individual measures. Exhibit 3-53 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the combined measure using the LIFEREG procedure. Exhibit 3-54 compares these five survival functions with the empirical survival function, over the first 48 months of the measure's life.

Exhibit 3-53
Comparison of Exponential Survival Functions
Based on LIFEREG Procedure
L37 HID >=176W, L81 HID 251-400W and Combined Measures

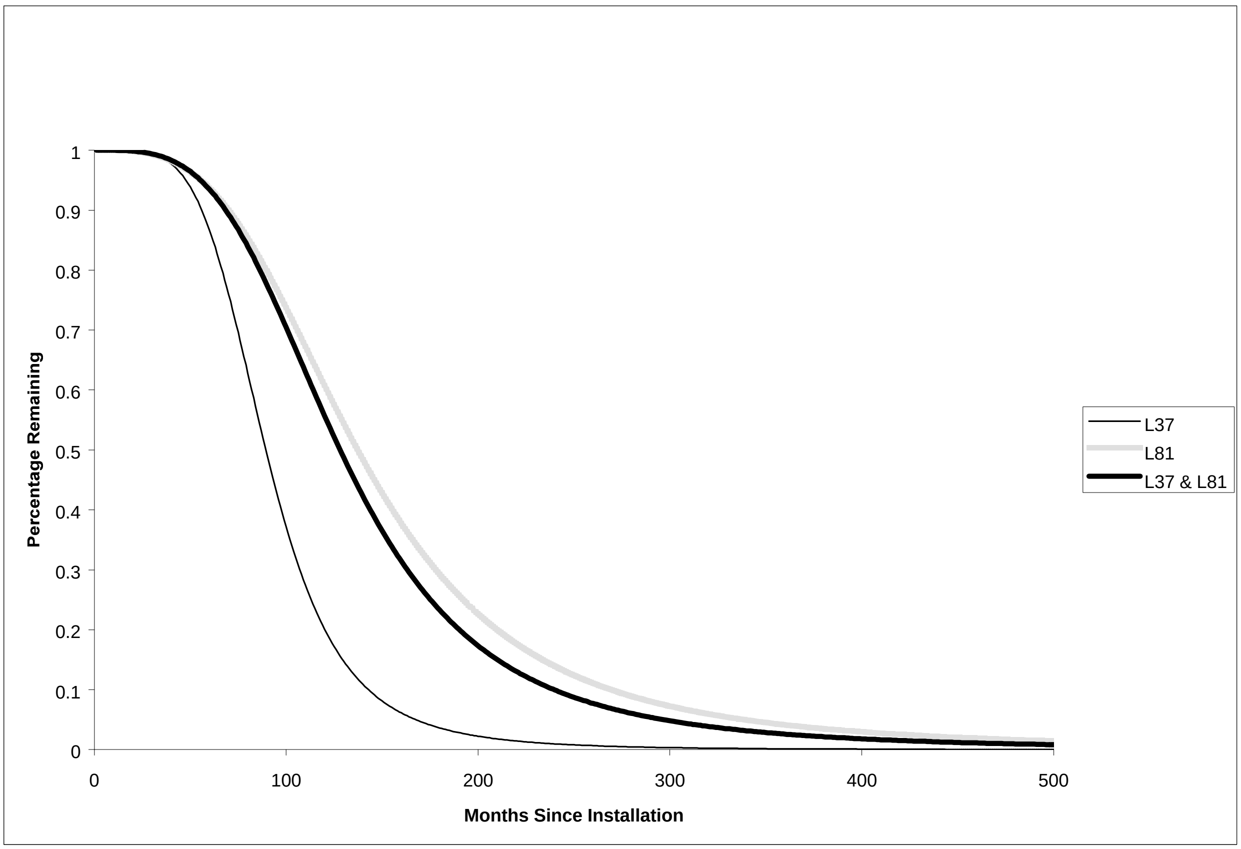


Exhibit 3-54
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
Combined L37 and L81 HID Measures

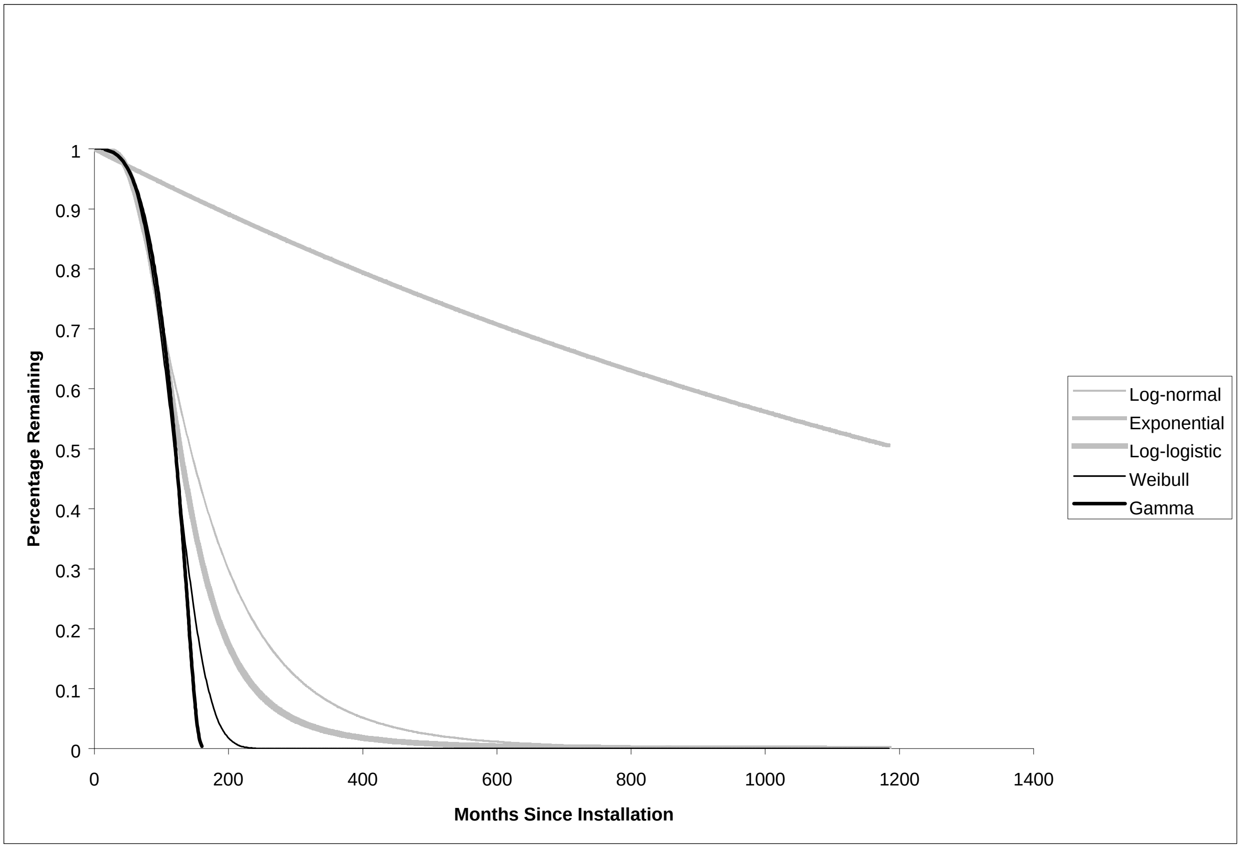


Exhibit 3-55
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
Combined L37 and L81 HID Measures

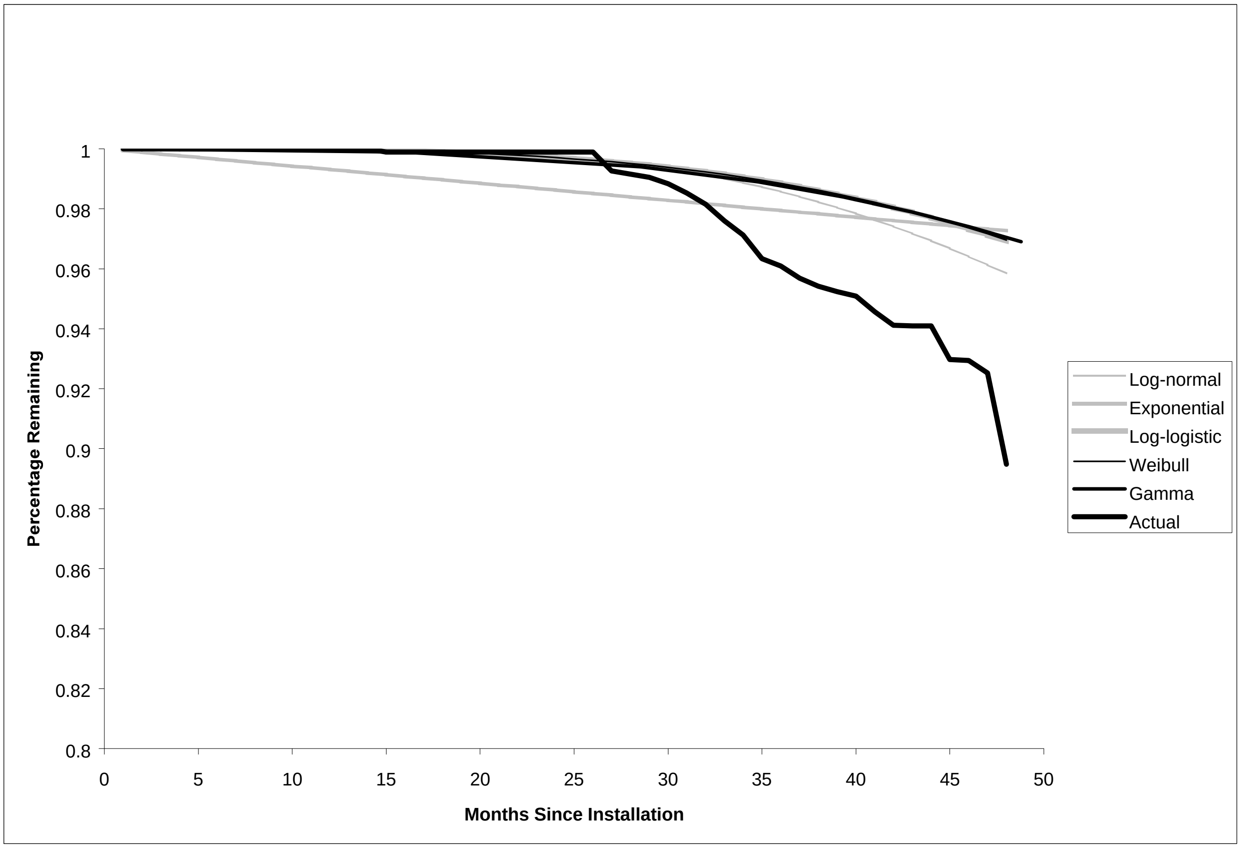


Exhibit 3-56 provides the estimated exponential survival function for the S22 ASD measure, and compares it with exponential trendline that was estimated based on the empirical survival function discussed above. Exhibit 3-57 compares the empirical survival function, with both the LIFEREG estimate of the exponential survival function and the exponential trendline, over the first 40 months of the measure's life.

Exhibit 3-56
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline
S22 ASD Measure

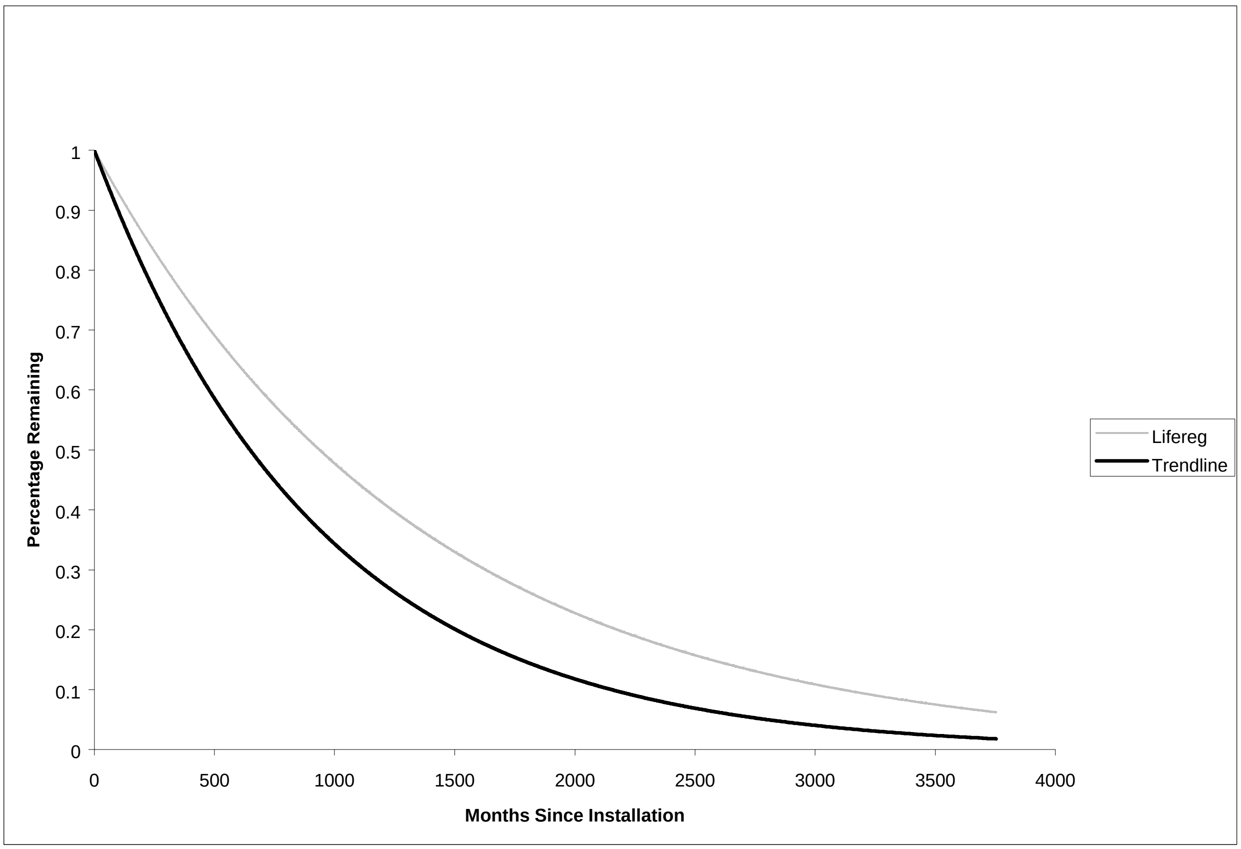


Exhibit 3-57
Comparison of Survival Functions
LIFEREG Exponential Model versus Exponential Trendline versus Empirical Function
S22 ASD Measure

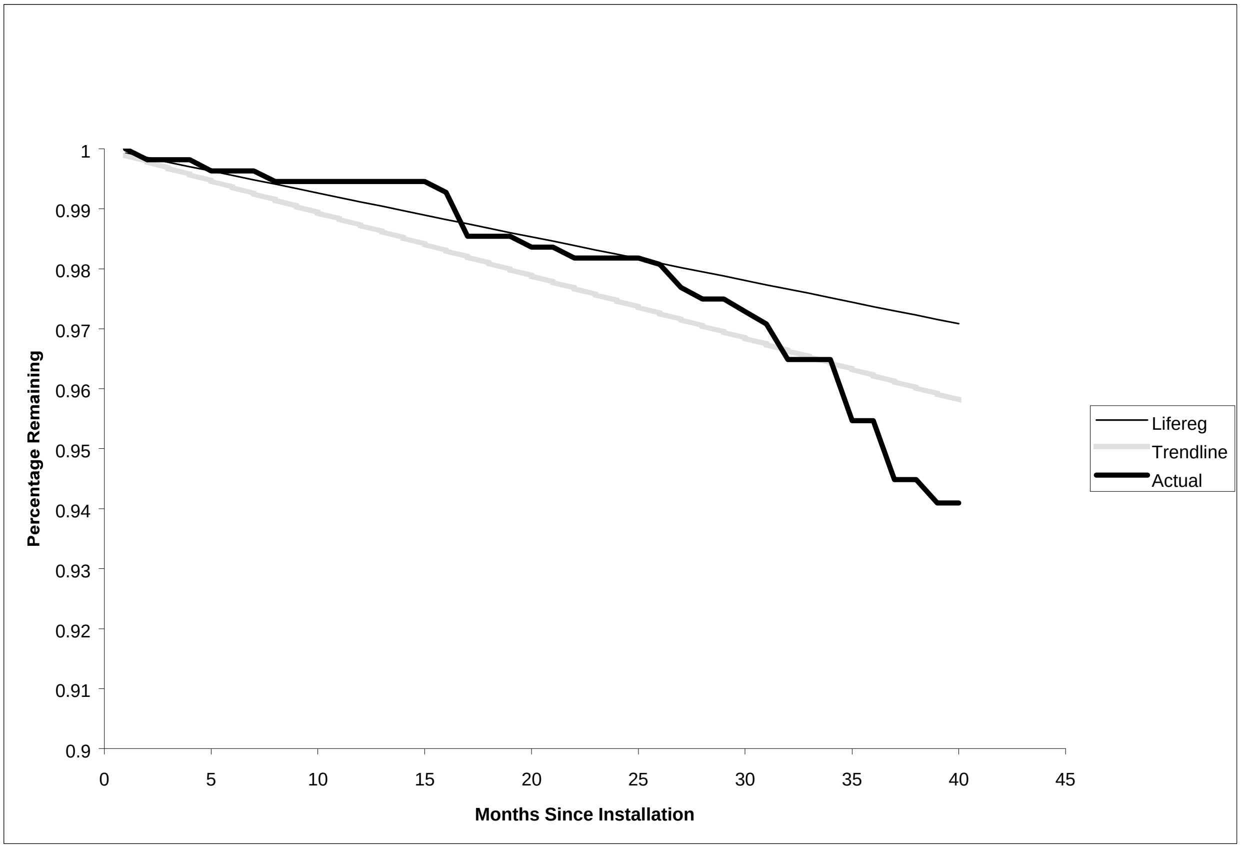


Exhibit 3-58 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the S22 ASD measure using the LIFEREG procedure. Exhibit 3-59 compares these five survival functions with the empirical survival function, over the first 40 months of the measure's life.

Exhibit 3-58
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
S22 ASD Measure

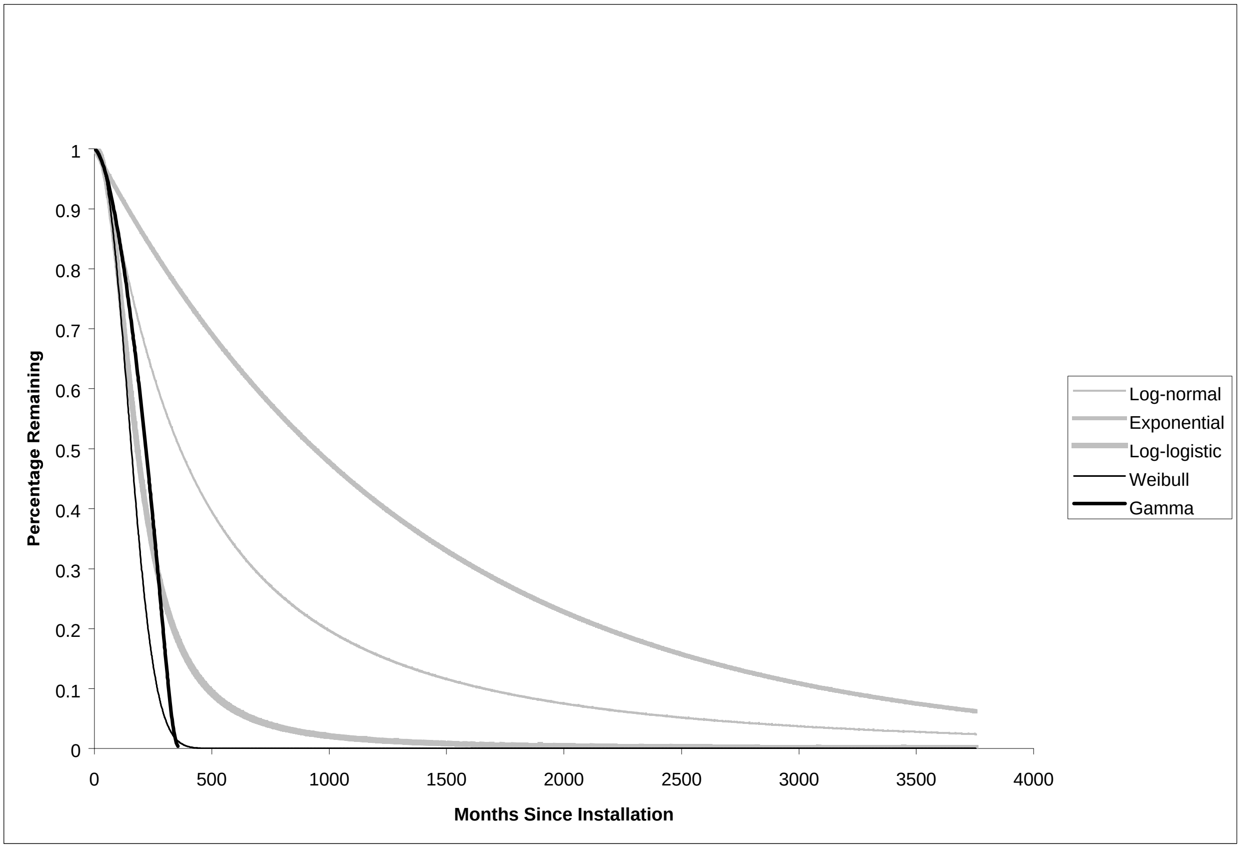


Exhibit 3-59
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
S22 ASD Measure

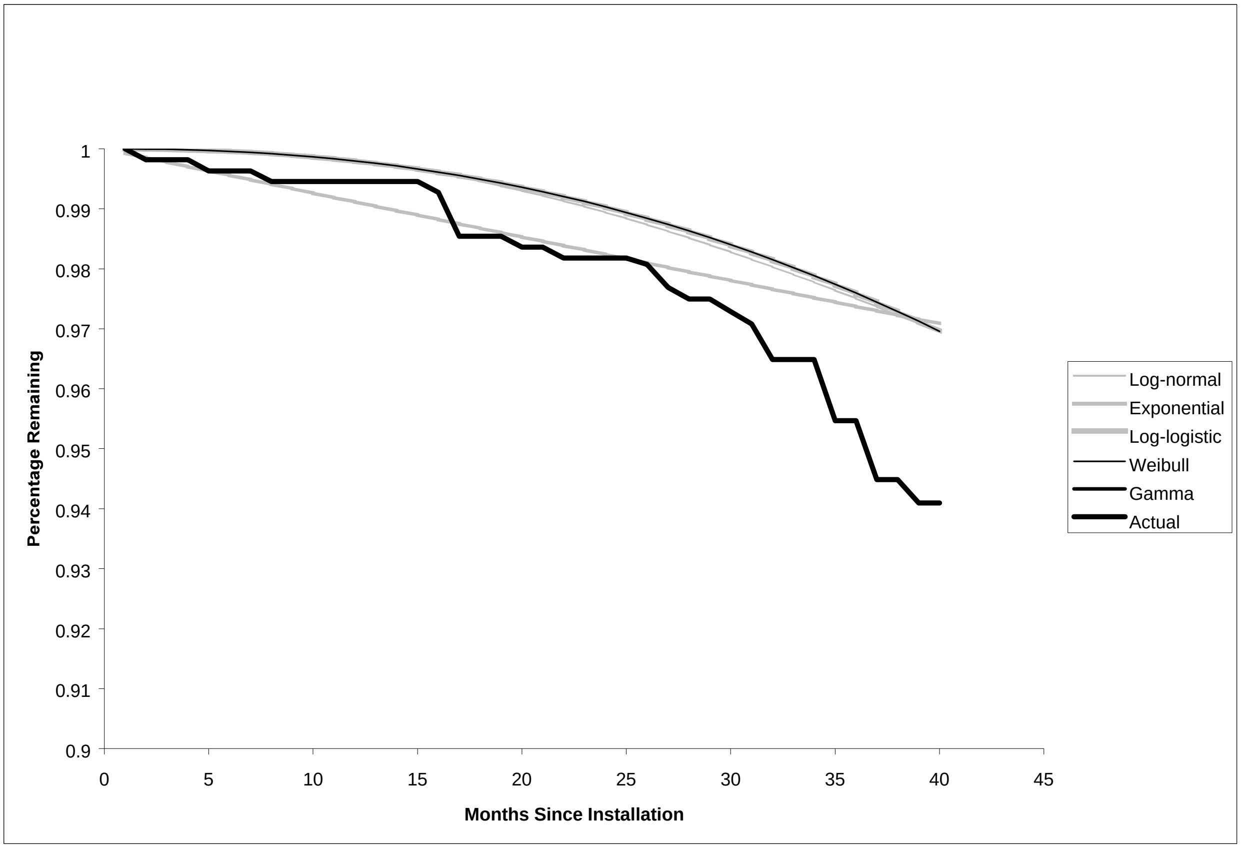


Exhibit 3-60 below summarizes all of the results of the LIFEREG models. Shown for each model are the parameter estimates and standard errors for every variable included in the model specification. Furthermore, the resulting EUL and its associated standard error are provided.

It should be noted that the standard errors that were directly output by SAS were adjusted to account for the correlation problem discussed earlier in Section 3.1. Recall that the failure and removal rates associated with measures installed at the same site are correlated. For example, when a removal occurs, it is likely that many measures are removed at once (as seen in our L37 HID >=176W data). To a lesser extent, failures are correlated since they may all come from the same manufacturing lot, they are all likely to be installed under the same circumstances, and they are also used in a similar manner. Attachment 3, Protocol Table 7B, discusses the development of standard errors in more detail.

Exhibit 3-60
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models
L23 T8, Combined L37 and L81 HID, and S22 ASD Measures

			Variable			Resulting
Measure	Model		Intercept	Scale	Ophours	EUL
L23	Exponential	Parameter Estimate	8.56	1.00	-0.00033	**89.1**
		Standard Error	3.60	0.00	0.00085	31.23
	Logistic	Parameter Estimate	6.36	0.54	-0.00019	**24.3**
		Standard Error	2.37	0.18	0.00053	15.79
	Log-Normal	Parameter Estimate	6.70	1.31	-0.00013	**41.8**
		Standard Error	2.17	0.42	0.00045	34.81
	Weibull	Parameter Estimate	6.42	0.55	-0.00019	**20.6**
		Standard Error	2.41	0.19	0.00053	12.25
	Gamma	Estimate	6.52	0.32	-0.00021	**20.2**
		Standard Error	2.40	0.10	0.00057	7.65
L37 and L81	Exponential	Parameter Estimate	14.17	1.00	-0.00177	**100.1**
		Standard Error	10.27	0.00	0.00240	47.24
	Logistic	Parameter Estimate	6.57	0.29	-0.00045	**10.7**
		Standard Error	3.98	0.13	0.00091	3.77
	Log-Normal	Parameter Estimate	6.08	0.63	-0.00030	**11.9**
		Standard Error	2.99	0.26	0.00066	5.23
	Weibull	Parameter Estimate	6.63	0.29	-0.00046	**9.9**
		Standard Error	4.02	0.13	0.00091	3.17
	Gamma	Estimate	7.25	0.10	-0.00058	**10.9**
		Standard Error	4.22	0.06	0.00098	5.72
S22	Exponential	Parameter Estimate	7.21	1.00	-	**78.1**
		Standard Error	1.12	0.00	-	87.42
	Logistic	Parameter Estimate	5.21	0.44	-	**15.3**
		Standard Error	2.12	0.59	-	32.35
	Log-Normal	Parameter Estimate	5.90	1.18	-	**30.4**
		Standard Error	2.85	1.44	-	86.65
	Weibull	Parameter Estimate	5.22	0.44	-	**13.2**
		Standard Error	2.14	0.59	-	25.38
	Gamma	Estimate	5.71	0.17	-	**18.3**
		Standard Error	0.67	0.20	-	12.25

Exhibit 3-61 compares the results of the LIFEREG models for the L37 HID >=176W and L81 HID 251-400W measures individually and combined. Because of the limited sample size for these two measures, the similarity of the two measures, and the significant influence that one customer has on the L37 HID >=176W result, we recommend combining these two measures. We still believe the results for the logistic, log-normal, Weibull and gamma models may be biased downwards since the one influential customer is still left in the model.

Section 4 provides the recommended results by studied measure, and summarizes all of the results developed in this section.

Exhibit 3-61
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models
L37 HID >=176W and L81 HID 251-400W versus Combined Measures

			Variable			Resulting
Measure	**Model**		**Intercept**	**Scale**	**Ophours**	**EUL**
L37	Exponential	Parameter Estimate	6.33	1.00	-	**32.5**
		Standard Error	0.58	0.00	-	18.73
	Logistic	Parameter Estimate	4.49	0.21	-	**7.5**
		Standard Error	0.31	0.12	-	2.30
	Log-Normal	Parameter Estimate	4.60	0.45	-	**8.3**
		Standard Error	0.36	0.24	-	2.99
	Weibull	Parameter Estimate	4.52	0.22	-	**7.1**
		Standard Error	0.32	0.13	-	1.97
	Gamma	Estimate	4.53	0.07	-	**6.8**
		Standard Error	0.13	0.04	-	0.87
L81	Exponential	Parameter Estimate	14.10	1.00	-0.00174	**107.7**
		Standard Error	10.61	0.00	0.00248	62.05
	Logistic	Parameter Estimate	6.84	0.31	-0.00051	**11.4**
		Standard Error	4.29	0.17	0.00096	5.75
	Log-Normal	Parameter Estimate	6.42	0.69	-0.00036	**13.3**
		Standard Error	3.43	0.36	0.00074	8.27
	Weibull	Parameter Estimate	6.88	0.31	-0.00051	**10.5**
		Standard Error	4.31	0.17	0.00096	6.55
	Gamma	Estimate	7.25	0.10	-0.00058	**10.9**
		Standard Error	4.22	0.06	0.00098	5.72
L37 and L81	Exponential	Parameter Estimate	14.17	1.00	-0.00177	**100.1**
		Standard Error	10.27	0.00	0.00240	47.24
	Logistic	Parameter Estimate	6.57	0.29	-0.00045	**10.7**
		Standard Error	3.98	0.13	0.00091	3.77
	Log-Normal	Parameter Estimate	6.08	0.63	-0.00030	**11.9**
		Standard Error	2.99	0.26	0.00066	5.23
	Weibull	Parameter Estimate	6.63	0.29	-0.00046	**9.9**
		Standard Error	4.02	0.13	0.00091	3.17
	Gamma	Estimate	6.91	0.11	-0.00052	**10.1**
		Standard Error	4.01	0.05	0.00093	4.93

4. RESULTS

This section presents the final results of the 1995 CEEI Retention Study. As discussed in detail in Section 3, the overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data.

2. ***Visually inspect*** the retention data.

3. ***Develop a trend line*** from the survival plots.

4. ***Develop a survival function*** using classical survival techniques.

4.1 COMPILE SUMMARY STATISTICS

For some measures, it was sufficient to only look at the raw data, because for some measures, all of the sampled equipment was still in place and operable. For measures that did exhibit some failures and removals, it was clear that such a small percentage of failures and removals had occurred, that it would be nearly impossible to model the equipment's survival function.

Exhibit 4-1 presents the percentage of measures that were found to have failed or been removed over the study period. From this percentage, an EUL was estimated, assuming a constant failure rate over the life of the measure.

Exhibit 4-1
Summary Statistics on Raw Retention Data

End Use	Technology	Measure	Percent Failed, Removed, Replaced	Annualized Failure, Removal, Replacement Rate^	Median Life*	Ex Ante EUL
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	0.04%	0.01%	5,077	16
	T8 Lamps and Electronic Ballasts	L23	2.08%	0.69%	100	16
	High Intensity Discharge	L37	9.14%	3.05%	23	16
		L81	4.54%	1.51%	46	16
HVAC	ASD	S22	2.74%	0.91%	76	16
	Chiller	S11	0.00%	0.00%	-	20
	Cooling Tower	S15	0.00%	0.00%	-	20
	EMS	204	4.76%	1.59%	44	14

^ Assuming a percentage of failed, removed, replaced occurs over three years.
* Assuming a constant failure rate over time.

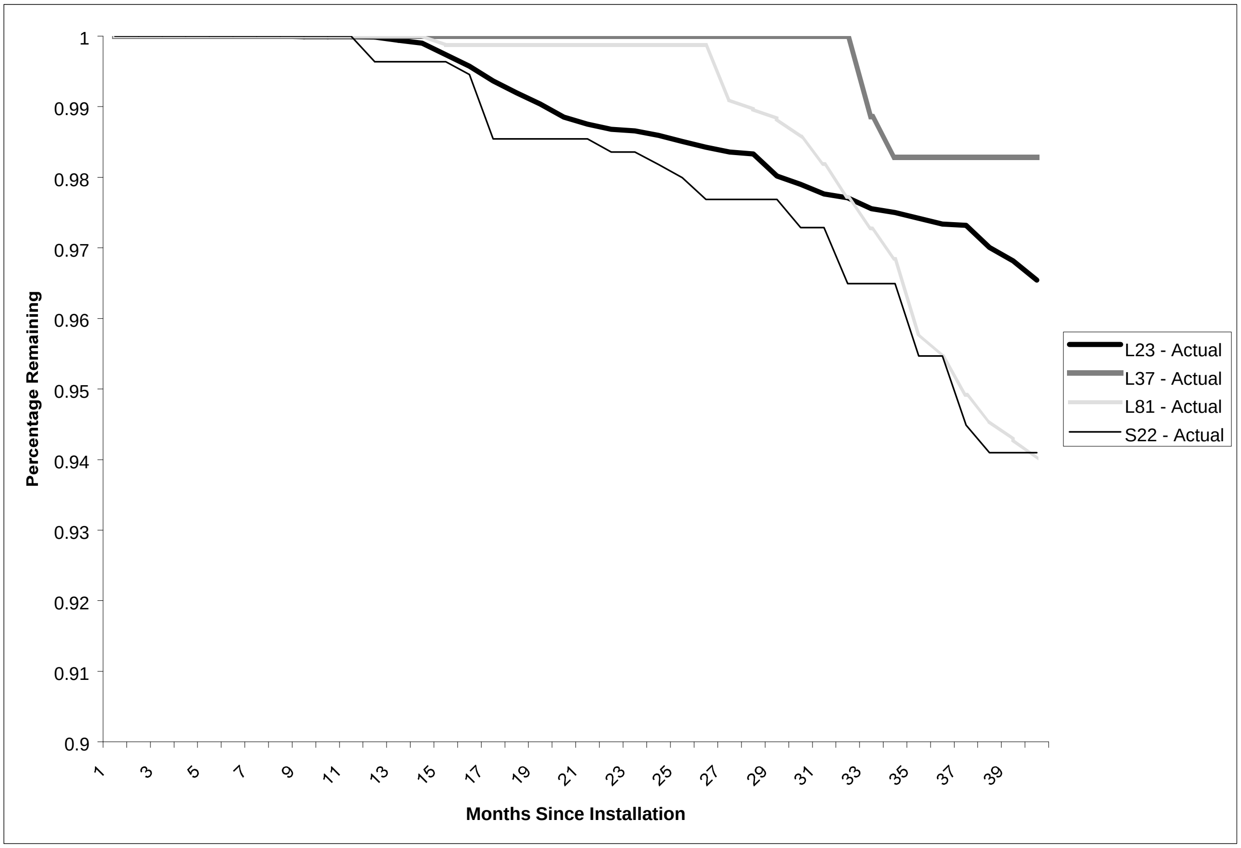
Exhibit 4-1 clearly demonstrates that for the S11 Chiller and S15 Cooling Tower measures, it will be impossible to develop a survival function or an ex post EUL estimate, since no failures or removals occurred during the study period. Furthermore, the L19 Delamp and 204 EMS measures exhibited only one or two failures or removals in the sample. With such limited data on failures, a reliable survival function cannot be developed nor can an ex post EUL estimate. Because of this, no further analysis was conducted on the S11 Chiller, S15 Cooling Tower, L19 Delamp, or 204 EMS measures. The ex ante estimate was assumed for the ex post estimate of the EUL for these four measures.

4.2 VISUAL INSPECTION

Using the raw retention data, we developed empirical distributions of the survival function for each of the studied measures. This step clearly illustrated that for each studied measure, there was not enough data over time to support an accurate estimate of the survival function. For this study, the vast majority of measures were in place less than five years (few were installed prior to 1994, and follow-up data collection was conducted no later than the end of 1998). Because the ex ante EUL is 15-20 years for most measures, our data were not capable of accurately estimating the survival function of failures and removals.

Exhibit 4-2 provides the empirical survival function for the four studied measures that had a sufficient number of failures occur during the study period to produce any survival function.

Exhibit 4-2
Empirical Survival Functions
L23 T8, L37 HID >=176W, L81 HID 251-400W and S22 ASD Measures



4.3 DEVELOP A TREND LINE

Using the empirical functions developed above, a trend line was estimated using standard linear regression techniques. We modeled the trend as a linear and an exponential function (by taking the log of the percentage operable). In each case, we plotted the resulting trend line and visually compared it to the empirical survival function developed above.

The results of the trendline regressions are provided in Exhibit 4-3 for each of the four measures. Also provided in Exhibit 4-3 is the estimated EUL for each measure. Clearly, the results of the linear and exponential trendline estimate indicate that the ex post EUL estimates are significantly larger than the ex ante estimates (which are all 16 years). Each of these results would easily reject the ex ante estimate at the 80 percent confidence level.

Exhibit 4-3
Regression Results of Linear and Exponential Trendlines and Resulting Ex Post EUL Estimates

Measure	Measure Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Linear Distribution						
L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	1.01	1,193	-0.0009	-25.67	46
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	1.01	279	-0.0013	-8.39	33
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	1.02	184	-0.0015	-8.59	29
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	1.01	490	-0.0015	-17.16	28
Exponential Distribution						
L23	FIXTURE: MODIFICATION / REPLACE LAMPS & BLST, 4 FT FIXTURE	-	-	0.0007	22.33	87
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	-	-	0.0008	8.26	76
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	-	-	0.0009	8.68	65
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	-	-	0.0011	17.27	54

4.4 DEVELOP A SURVIVAL FUNCTION

Using classical survival techniques, we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed above. Furthermore, we used the resulting survival function to estimate the EUL.

Because of the limited sample sizes for the L37 HID >=176W and L81 HID 251-400W measures, and because of one customer who exerted significant influence on the L37 HID >=176W models, we combined these two measures. This is further justified by the fact that both measures share the same set of like measures.

Exhibit 4-4 provides the results of the classical survival analysis. Shown are the model results for each measure, and for each type of distribution modeled. Furthermore, the resulting EUL estimates are provided.

Exhibit 4-4
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models
L23 T8, Combined L37 and L81 HID, and S22 ASD Measures

Measure	Model		Variable			Resulting
			Intercept	Scale	Ophours	EUL
L23	Exponential	Parameter Estimate	8.56	1.00	-0.00033	**89.1**
		Standard Error	3.60	0.00	0.00085	31.23
	Logistic	Parameter Estimate	6.36	0.54	-0.00019	**24.3**
		Standard Error	2.37	0.18	0.00053	15.79
	Log-Normal	Parameter Estimate	6.70	1.31	-0.00013	**41.8**
		Standard Error	2.17	0.42	0.00045	34.81
	Weibull	Parameter Estimate	6.42	0.55	-0.00019	**20.6**
		Standard Error	2.41	0.19	0.00053	12.25
	Gamma	Estimate	6.52	0.32	-0.00021	**20.2**
		Standard Error	2.40	0.10	0.00057	7.65
L37 and L81	Exponential	Parameter Estimate	14.17	1.00	-0.00177	**100.1**
		Standard Error	10.27	0.00	0.00240	47.24
	Logistic	Parameter Estimate	6.57	0.29	-0.00045	**10.7**
		Standard Error	3.98	0.13	0.00091	3.77
	Log-Normal	Parameter Estimate	6.08	0.63	-0.00030	**11.9**
		Standard Error	2.99	0.26	0.00066	5.23
	Weibull	Parameter Estimate	6.63	0.29	-0.00046	**9.9**
		Standard Error	4.02	0.13	0.00091	3.17
	Gamma	Estimate	7.25	0.10	-0.00058	**10.9**
		Standard Error	4.22	0.06	0.00098	5.72
S22	Exponential	Parameter Estimate	7.21	1.00	-	**78.1**
		Standard Error	1.12	0.00	-	87.42
	Logistic	Parameter Estimate	5.21	0.44	-	**15.3**
		Standard Error	2.12	0.59	-	32.35
	Log-Normal	Parameter Estimate	5.90	1.18	-	**30.4**
		Standard Error	2.85	1.44	-	86.65
	Weibull	Parameter Estimate	5.22	0.44	-	**13.2**
		Standard Error	2.14	0.59	-	25.38
	Gamma	Estimate	5.71	0.17	-	**18.3**
		Standard Error	0.67	0.20	-	12.25

4.5 FINAL RESULTS

Exhibit 4-5 summarizes the estimated EULs for each studied measure for each approach and corresponding model. The median EULs are provided, along with the upper and lower confidence bounds, based on the 80 percent confidence interval. For the L19 Delamp, S11 Chiller, S15 Cooling Tower and 204 EMS measures, there was not a sufficient number of failures or removals to estimate an ex post EUL. Therefore, as per the Protocols, for these four measures the ex ante estimate of the EUL is retained.

Exhibit 4-5
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models
L23 T8, Combined L37 and L81 HID, and S22 ASD Measures

			Measures							
Approach	**Model**		**L19**	**L23**	**L37**	**L81**	**S11**	**S15**	**S22**	**204**
Summary Statistics	Exponential	Median EUL	5,077	100	23	46	-	-	76	44
		Upper Bound	-	-	-	-	-	-	-	-
		Lower Bound	-	-	-	-	-	-	-	-
Trendlines	Linear	Median EUL	-	46	33	29	-	-	28	-
		Upper Bound	-	48	38	34	-	-	30	-
		Lower Bound	-	44	28	25	-	-	26	-
	Exponential	Median EUL	-	87	76	65	-	-	54	-
		Upper Bound	-	92	87	75	-	-	58	-
		Lower Bound	-	82	64	55	-	-	50	-
LIFEREG	Exponential	Median EUL	-	89	100	100	-	-	78	-
		Upper Bound		129	161	161			190	
		Lower Bound	-	49	40	40	-	-	-34	-
	Logistic	Median EUL	-	24	11	11	-	-	15	-
		Upper Bound		44	15	15			57	
		Lower Bound	-	4	6	6	-	-	-26	-
	Log-Normal	Median EUL	-	42	12	12	-	-	30	-
		Upper Bound		86	19	19			141	
		Lower Bound	-	-3	5	5	-	-	-81	-
	Weibull	Median EUL	-	21	10	10	-	-	13	-
		Upper Bound		36	14	14			46	
		Lower Bound	-	5	6	6	-	-	-19	-
	Gamma	Median EUL	-	20	11	11	-	-	18	-
		Upper Bound		30	18	18			34	
		Lower Bound	-	10	4	4	-	-	3	-

Before recommending a methodology to estimate the ex post EUL for the remaining four measures, it is first important to consider the definition of a confidence interval. Most people mistakenly interpret an 80 percent confidence interval, for example, to mean that there is an 80 percent probability that the true median EUL is contained within the interval provided. This is ***not*** true. The correct interpretation of an 80 percent confidence interval is that if a given experiment is repeated a large enough number of times (say 30 or more), the median obtained from the same model will be contained in the confidence interval 80 percent of the time.

Take for example the exponential distribution modeled for the L23 T8 measure, using the LIFEREG procedure. If we were to repeat our experiment and create a retention panel of 138 sites with 12,085 units originally installed (as was done for this study), there would be an 80 percent probability that the resulting median EUL using the exponential LIFEREG model would result in a value between 49 and 129 years.

Therefore, the results presented above should not be interpreted as data intervals which have an 80 percent probability of containing the true median EUL. One common use of confidence intervals is to identify models that provide results that are not statistically significantly different than zero. As we can see above, many of our model results are not statistically significantly different than zero when measured at the 80 percent confidence level. In fact, the only model from the LIFEREG procedure that produces a statistically significant result for all measures is the gamma distribution.

We point this all out, because based on our extensive analysis of the retention data, we believe that there is insufficient data to provide reliable model results. There may be sufficient sample sizes to produce statistically significant results, but there clearly is not enough data over time to reliably estimate the median EUL. This can be illustrated by the sensitivity in the model results.

Take, for example, the five model results based on the LIFEREG procedure for the L23 T8 measure. The median EUL based on the exponential distribution was 89 years, versus only 20 years using the gamma distribution. If we had a sufficient amount of data over time, such that the retention data actually covered the true median, we would expect the median result for the two models to be extremely close! Recall that only about 40 months of valid data was collected for this measure, and that the ex ante EUL is 192 months. After 40 months, the gamma distribution actually estimated fewer failure/removals than the exponential distribution, as shown below in Exhibit 4-6.

Exhibit 4-6
Comparison of Survival Functions
Exponential and Gamma versus Empirical Function
L23 T8 Measure

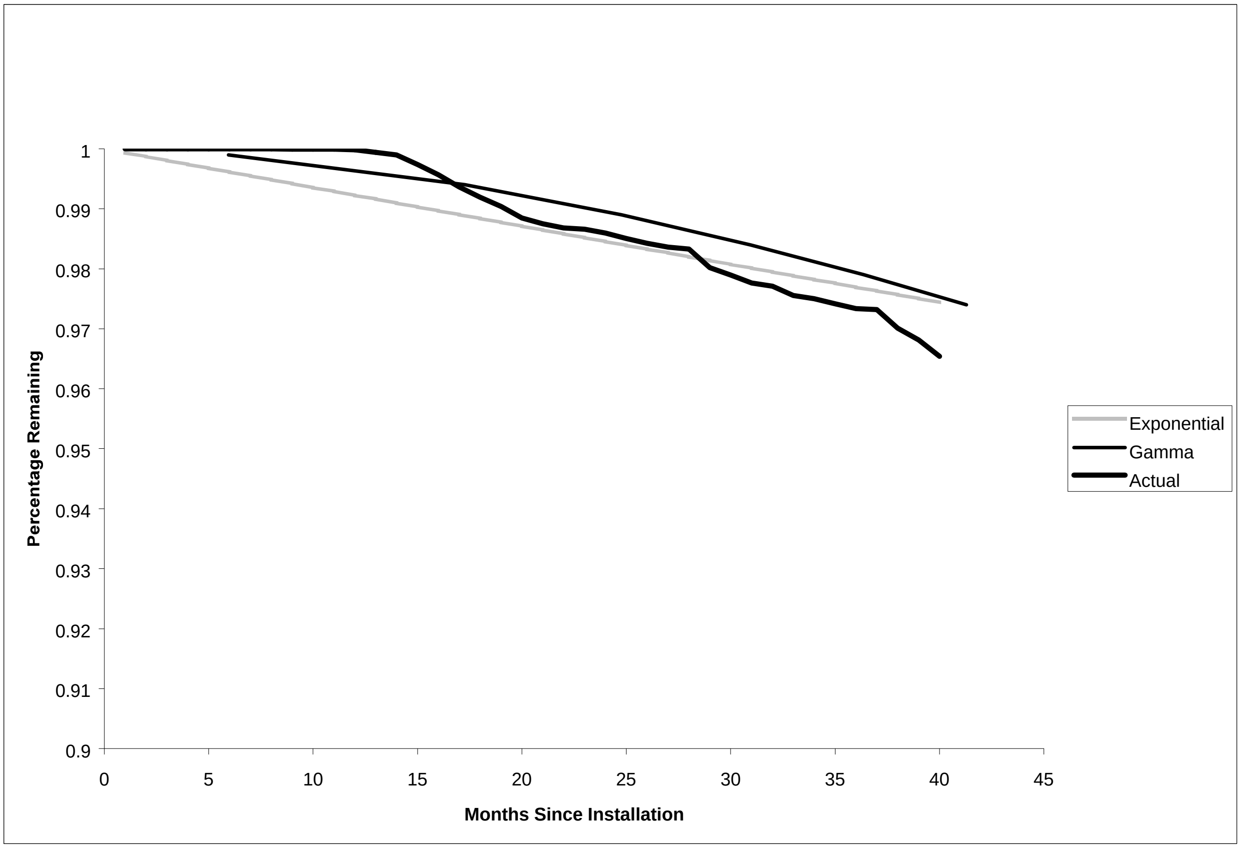
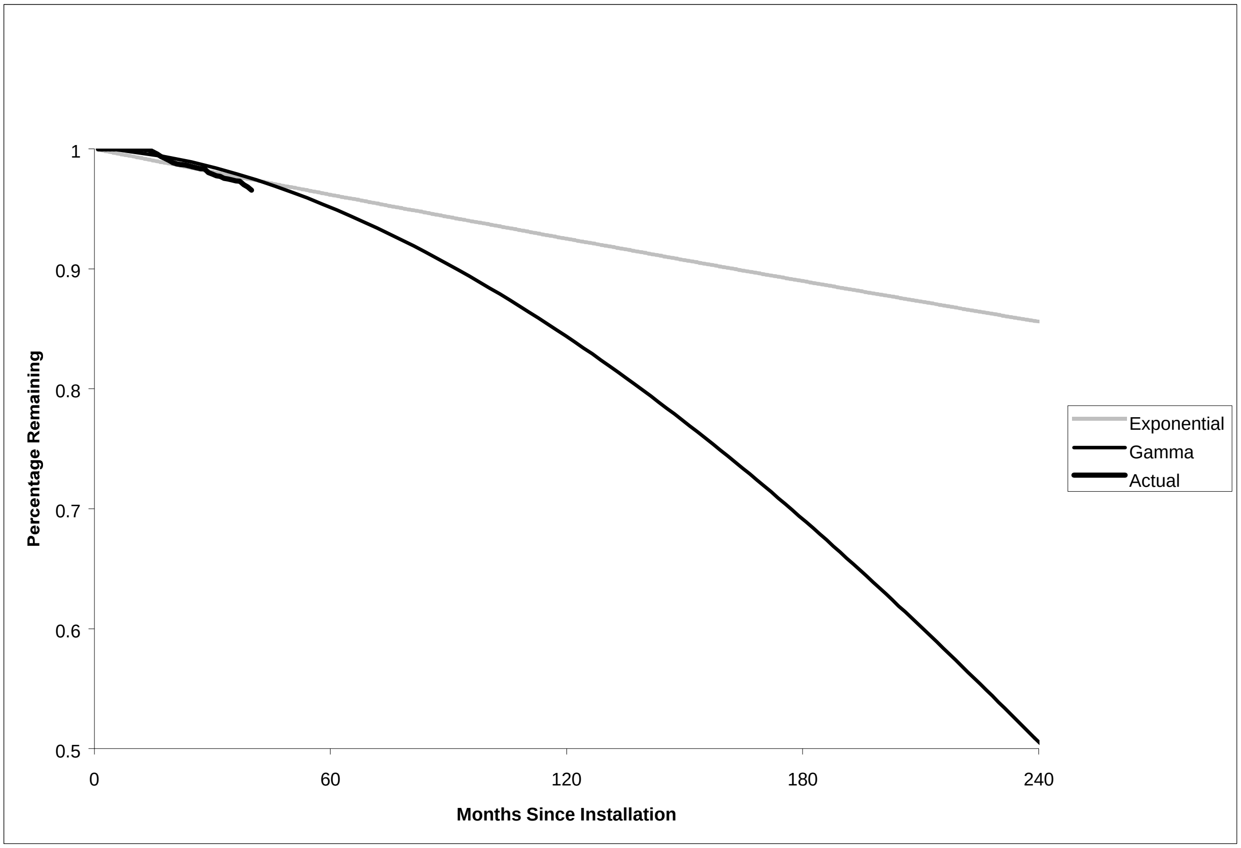


Exhibit 4-6 further illustrates how close the two models estimate the empirical survival function, and how close the two models are to each other. Beyond the 40 months, however, there is little data for the model to structure the remaining survival function. Consider what happens over the next 200 months, up to the 20th year. As shown in Exhibit 4-7, in year 20, the gamma model has reached its median point; whereas the exponential distribution still predicts that 85 percent of the measures are in place and operable. Which model result is better?

Clearly at this point in the measure's life it is not possible to state with much certainty, which model result is superior to the other. Yet, the Protocols require an ex post estimate of the EUL during the fourth year study, and if the ex post estimate is statistically significantly different than the ex ante estimate at the 80 percent confidence level, then we accept the ex post estimate. Under this guideline, one could select the exponential results, which are statistically significantly different than the ex ante estimate at the 80 percent confidence level for three measures, and provide EULs that are as much as six times larger than ex ante. Conversely, we could select the log-normal or gamma results which are not statistically significantly different than the ex ante results for any measure.

Exhibit 4-7
Comparison of Survival Functions Over 20 Years
Exponential and Gamma versus Empirical Function
L23 T8 Measure



Our recommendation would be to discard all of the model results on the basis that there is insufficient data over the life of the measures. We want to stress that we believe the sample sizes are sufficient. It is only that we have not observed the sample over a long enough period of time. However, because we are required by the Protocols to report a study result, we will select one of the approaches as our recommended result.

For the four measures that had sufficient failures and removals, all approaches discussed in Section 3 were implemented. The results based on the summary statistics are not recommended, as they based solely on the overall failure/removal rate observed during the study period. In addition, the results based on the trendlines are not recommended, as they are based on a number of assumptions, as discussed earlier.

Therefore, the recommended results are based on the classical survival analysis using the LIFEREG procedure. Of the five distributions modeled, the gamma distribution is the most adaptive. The LIFEREG procedure models the generalized gamma distribution, which has three parameters. Because this model has at least one more parameter than any of the other distributions, it can take on a wide variety of shapes. In addition, the exponential, Weibull and log-normal distributions are all special cases of the generalized gamma model. But the generalized gamma model can also take on shapes that are unlike any of these special cases. Most importantly, it can have hazard functions with U or bathtub shapes, in which the failure rate (or hazard function) declines, reaches a minimum, and then increases.

Intuitively, then, one would expect the gamma results to provide a better model fit than either the exponential, Weibull or log-normal models (since these are all special cases of the gamma model). As expected, the gamma distribution generally provided the best model fit, as measured by the log-likelihood estimate provided by the LIFEREG procedure. Furthermore, the gamma model is the distribution that provided a result for each measure that was statistically significantly different than zero, measured at the 80% confidence interval[1]. For these reasons, we recommend that the survival function be based on the gamma distribution.

Exhibit 4-8 presents the recommended ex post estimates of the EUL. Because the gamma model did not provide results that were statistically significantly different from the ex ante results, measured at the 80 percent confidence interval, all of the ex post EULs are based on the ex ante estimates. The ex post estimates are compared to the favored study results, and the corresponding upper and lower 80 percent confidence interval, when available. Finally, the program realization rates are provided, which are the ratio of the ex ante and ex post estimates. For all measures, the realization rate is one.

Exhibit 4-8
Final Ex Post EUL Estimates

End Use	Technology	Measure	Ex Ante	Study Results Upper	Study Results Median	Study Results Lower	Ex Post	Realization Rate
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	16	-	-	-	16	100%
	T8 Lamps and Electronic Ballasts	L23	16	30	20	10	16	100%
	High Intensity Discharge	L37	16	18	11	4	16	100%
	High Intensity Discharge	L81	16	18	11	4	16	100%
HVAC	ASD	S22	16	34	18	3	16	100%
	Chiller	S11	20	-	-	-	20	100%
	Cooling Tower	S15	20	-	-	-	20	100%
	EMS	204	14	-	-	-	14	100%

[1] Please note that a result with a smaller standard error does not indicate that the model is a better fit. For example, a gamma distribution with a large standard deviation may be a much better fit than an exponential distribution with a small standard deviation. However, because the gamma distribution has a larger standard deviation, it will also have a larger standard error if the sample size is the same, since the standard error is equal to the sample standard deviation divided by the square root of the sample size.

Attachments

Attachment 1

Raw Retention Results

Exhibit Attachment 1 - 1
Summary of Raw Retention Data

	Technology	Measure	Number of Sites	Number of Items Purchased	Units	Total Number of Units	Number of Working Units	Percent Removed	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty	Number of Undeter-mined Units	Measure Life
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	51	51	Lamps	4883	4865	0.04%	2	0	16	16
	T8 Lamps and Electronic Ballasts	L23	138	138	Ballasts	12085	11545	2.08%	361	110	179	16
	High Intensity Discharge	L37	13	13	Fixtures	175	158	9.14%	17	1	0	16
		L81	34	34	Fixtures	771	709	4.54%	35	0	27	16
HVAC	VSD	S22	16	29	hp	548	488	2.74%	15	0	75	16
	Chiller	S11	7	9	Tons	4834	4834	0.00%	0	0	0	20
	Cooling Tower	S15	24	25	tons	10022	9871	0.00%	0	0	151	20
	EMS	204	21	21	Systems	21	20	4.76%	1	0	0	14

Exhibit Attachment 1 - 2
L19 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
107361	1	1	Lamps	24	24	0			0	100%	1/27/94		09/01/98	16
125808	1	1	Lamps	382	382	0			0	100%	8/9/94		12/01/97	16
490215	1	1	Lamps	50	50	0			0	100%	3/17/94		12/01/97	16
541969	1	1	Lamps	14	14	0			0	100%	11/30/95		09/01/98	16
683929	1	1	Lamps	14	14	0			0	100%	5/11/95		12/01/97	16
832509	1	1	Lamps	10	10	0			0	100%	8/31/95		12/01/97	16
832509	1	1	Lamps	260	260	0			0	100%	8/31/95		12/01/97	16
834763	1	1	Lamps	45	45	0			0	100%	12/28/94		09/01/98	16
847542	1	1	Lamps	6	6	0			0	100%	12/20/95		12/01/97	16
849114	1	1	Lamps	16	16	0			0	100%	9/21/95		09/01/98	16
851756	1	1	Lamps	39	39	0			0	100%	8/17/95		09/01/98	16
855207	1	1	Lamps	44	44	0			0	100%	5/25/95		12/01/97	16
865139	1	1	Lamps	258	258	0			0	100%	2/27/95		12/01/97	16
889180	1	1	Lamps	4	4	0			0	100%	4/6/95		12/01/97	16
902812	1	1	Lamps	6	6	0			0	100%	3/31/94		09/01/98	16
902812	1	1	Lamps	318	318	0			0	100%	3/31/94		09/01/98	16
902812	1	1	Lamps	360	360	0			0	100%	3/31/94		09/01/98	16
932228	1	1	Lamps	34	34	0			0	100%	1/24/94		09/01/98	16
932228	1	1	Lamps	128	128	0			0	100%	1/24/94		09/01/98	16
987290	1	1	Lamps	20	6	0			14	30%	12/20/95		12/01/97	16
1040899	1	1	Lamps	20	20	0			0	100%	2/27/95		09/01/98	16
1061534	1	1	Lamps	217	217	0			0	100%	12/20/95		12/01/97	16
1894224	1	1	Lamps	60	60	0			0	100%	12/29/95		09/01/98	16
1903655	1	1	Lamps	8	8	0			0	100%	5/6/94		12/01/97	16
1903655	1	1	Lamps	50	50	0			0	100%	5/6/94		12/01/97	16
2427939	1	1	Lamps	6	6	0			0	100%	10/4/94		09/01/98	16
2427939	1	1	Lamps	30	28	2			0	93%	10/4/94		09/01/98	16
3747470	1	1	Lamps	144	144	0			0	100%	9/9/94		12/01/97	16
3906484	1	1	Lamps	40	40	0			0	100%	12/29/95		12/01/97	16
4008825	1	1	Lamps	218	218	0			0	100%	8/25/94		09/01/98	16
4113327	1	1	Lamps	74	74	0			0	100%	5/10/94		12/01/97	16
4147678	1	1	Lamps	15	15	0			0	100%	8/11/95		12/01/97	16

Exhibit Attachment 1 - 2

L19 Survival Information

4165965	1	1	Lamps	8	8	0			0	100%	3/10/95		12/01/97	16
4180405	1	1	Lamps	60	60	0			0	100%	2/27/95		12/01/97	16
4193320	1	1	Lamps	36	36	0			0	100%	9/21/95		12/01/97	16
4269623	1	1	Lamps	19	19	0			0	100%	2/11/94		09/01/98	16
4304568	1	1	Lamps	18	18	0			0	100%	2/15/95		12/01/97	16
4404297	1	1	Lamps	59	59	0			0	100%	11/22/94		12/01/97	16
4453332	1	1	Lamps	28	28	0			0	100%	6/9/94		12/01/97	16
4485679	1	1	Lamps	36	36	0			0	100%	1/27/95		09/01/98	16
4541246	1	1	Lamps	4	4	0			0	100%	3/6/95		12/01/97	16
4687838	1	1	Lamps	640	640	0			0	100%	3/24/94		12/01/97	16
4687838	1	1	Lamps	640	640	0			0	100%	3/24/94		12/01/97	16
5036687	1	1	Lamps	60	60	0			0	100%	3/10/95		09/01/98	16
5058685	1	1	Lamps	10	10	0			0	100%	10/12/95		09/01/98	16
5347942	1	1	Lamps	52	52	0			0	100%	3/30/95		09/01/98	16
5362533	1	1	Lamps	16	14	0			2	88%	12/13/95		09/01/98	16
5368471	1	1	Lamps	214	214	0			0	100%	5/11/95		12/01/97	16
5528310	1	1	Lamps	13	13	0			0	100%	12/29/95		12/01/97	16
5538028	1	1	Lamps	12	12	0			0	100%	3/8/94		12/01/97	16
6073039	1	1	Lamps	44	44	0			0	100%	3/6/95		12/01/97	16
Total	51	51	Lamps	4883	4865	2			16	99.6%				16

Exhibit Attachment 1 - 3
L23 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
74963	1	1	Ballasts	19	18	1			0	95%	06/27/94	11/01/97	12/01/97	16
117705	1	1	Ballasts	44	44	0			0	100%	06/29/95		12/01/97	16
125808	1	1	Ballasts	173	173	0			0	100%	08/09/94		12/01/97	16
207716	1	1	Ballasts	256	256	0			0	100%	04/06/95		12/01/97	16
250275	1	1	Ballasts	5	5	0			0	100%	03/06/95		12/01/97	16
443481	1	1	Ballasts	280	280	0			0	100%	06/30/94		12/01/97	16
487688	1	1	Ballasts	24	24	0			0	100%	08/17/95		12/01/97	16
541969	1	1	Ballasts	7	7	0			0	100%	11/30/95		09/01/98	16
644913	1	1	Ballasts	1	1	0			0	100%	06/21/94		12/01/97	16
644913	1	1	Ballasts	2	2	0			0	100%	06/21/94		12/01/97	16
644913	1	1	Ballasts	12	12	0			0	100%	06/21/94		12/01/97	16
655635	1	1	Ballasts	15	14	1			0	93%	12/22/95		12/01/97	16
655635	1	1	Ballasts	28	27	1			0	96%	12/22/95		12/01/97	16
655635	1	1	Ballasts	29	27	2			0	93%	12/22/95		12/01/97	16
655635	1	1	Ballasts	54	52	2			0	96%	12/22/95		12/01/97	16
655635	1	1	Ballasts	128	122	6			0	95%	12/22/95		12/01/97	16
677006	1	1	Ballasts	96	95	1	0	1	0	99%	12/07/95	06/15/98	09/01/98	16
677006	1	1	Ballasts	150	148	2	0	2	0	99%	12/07/95	01/15/98	09/01/98	16
683929	1	1	Ballasts	175	175	0			0	100%	05/11/95		12/01/97	16
786477	1	1	Ballasts	4	4	0			0	100%	10/21/94		09/01/98	16
786477	1	1	Ballasts	30	27	3	3	0	0	100%	10/21/94	05/15/97	09/01/98	16
786477	1	1	Ballasts	158	121	2	2	0	35	78%	10/21/94	05/15/98	09/01/98	16
797054	1	1	Ballasts	8	5	0			3	63%	12/29/95		12/01/97	16
849114	1	1	Ballasts	46	38	8	8	0	0	100%	09/21/95	01/01/98	09/01/98	16
849600	1	1	Ballasts	12	12	0			0	100%	07/22/94		12/01/97	16
849600	1	1	Ballasts	33	33	0			0	100%	07/22/94		12/01/97	16
849600	1	1	Ballasts	292	292	0			0	100%	07/22/94		12/01/97	16
851756	1	1	Ballasts	20	20	0			0	100%	08/17/95		09/01/98	16
853737	1	1	Ballasts	32	15	0			17	47%	12/29/95		12/01/97	16
853769	1	1	Ballasts	120	120	0			0	100%	01/09/95		12/01/97	16
855207	1	1	Ballasts	32	32	0			0	100%	05/25/95		12/01/97	16

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L23 Survival Information

856513	1	1	Ballasts	136	134	2			0	99%	03/15/95		12/01/97	16
860115	1	1	Ballasts	259	258	1			0	100%	09/19/94		12/01/97	16
865139	1	1	Ballasts	144	144	0			0	100%	02/27/95		12/01/97	16
865139	1	1	Ballasts	151	151	0			0	100%	12/22/95		12/01/97	16
889180	1	1	Ballasts	28	14	0			14	50%	04/06/95		12/01/97	16
890577	1	1	Ballasts	12	12	0			0	100%	02/17/94		12/01/97	16
890577	1	1	Ballasts	12	12	0			0	100%	02/17/94		12/01/97	16
890577	1	1	Ballasts	24	24	0			0	100%	02/17/94		12/01/97	16
894737	1	1	Ballasts	195	193	2			0	99%	07/20/94	03/15/98	09/01/98	16
916040	1	1	Ballasts	136	136	0			0	100%	04/26/94		12/01/97	16
927944	1	1	Ballasts	14	7	7	3	4	0	71%	06/05/95		09/01/98	16
927944	1	1	Ballasts	40	20	20	10	10	0	75%	06/05/95		09/01/98	16
932228	1	1	Ballasts	17	15	2	2	0	0	100%	01/24/94	07/01/95	09/01/98	16
932228	1	1	Ballasts	64	40	2			22	63%	01/24/94	07/01/95	09/01/98	16
978299	1	1	Ballasts	49	49	0			0	100%	04/26/94		12/01/97	16
985672	1	1	Ballasts	29	27	0			2	93%	07/22/94		12/01/97	16
987290	1	1	Ballasts	342	342	0			0	100%	12/20/95		12/01/97	16
1022304	1	1	Ballasts	36	36	0			0	100%	09/21/95		12/01/97	16
1029584	1	1	Ballasts	20	20	0			0	100%	12/19/94		12/01/97	16
1029584	1	1	Ballasts	29	29	0			0	100%	12/19/94		12/01/97	16
1029623	1	1	Ballasts	31	31	0			0	100%	07/22/94		12/01/97	16
1029623	1	1	Ballasts	62	62	0			0	100%	07/22/94		12/01/97	16
1035061	1	1	Ballasts	16	16	0			0	100%	10/04/94		09/01/98	16
1035061	1	1	Ballasts	111	111	0			0	100%	10/04/94		09/01/98	16
1040899	1	1	Ballasts	10	6	4	4	0	0	100%	02/27/95	09/15/95	09/01/98	16
1044949	1	1	Ballasts	76	76	0			0	100%	09/01/94		12/01/97	16
1055159	1	1	Ballasts	9	9	0			0	100%	06/23/95		12/01/97	16
1061534	1	1	Ballasts	8	8	0			0	100%	12/20/95		12/01/97	16
1061534	1	1	Ballasts	109	109	0			0	100%	12/20/95		12/01/97	16
1073857	1	1	Ballasts	24	24	0			0	100%	09/21/95		09/01/98	16
1095075	1	1	Ballasts	41	41	0			0	100%	05/10/94		12/01/97	16
1100592	1	1	Ballasts	8	8	0			0	100%	02/15/95		12/01/97	16
1215824	1	1	Ballasts	23	18	5	5	0	0	100%	03/24/94	03/15/97	09/01/98	16
1340058	1	1	Ballasts	2	2	0			0	100%	05/02/94		12/01/97	16

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L23 Survival Information

1340058	1	1	Ballasts	5	5	0			0	100%	05/02/94		12/01/97	16
1539514	1	1	Ballasts	4	4	0			0	100%	06/03/94		12/01/97	16
1539514	1	1	Ballasts	124	124	0			0	100%	04/05/94		12/01/97	16
1894224	1	1	Ballasts	30	15	15	4	11	0	63%	12/29/95	07/01/97	09/01/98	16
1903655	1	1	Ballasts	4	4	0			0	100%	05/06/94		12/01/97	16
1903655	1	1	Ballasts	25	25	0			0	100%	05/06/94		12/01/97	16
2398478	1	1	Ballasts	16	16	0			0	100%	04/26/94		12/01/97	16
2454686	1	1	Ballasts	13	13	0			0	100%	07/20/94		09/01/98	16
2459126	1	1	Ballasts	48	48	0			0	100%	04/27/95		09/01/98	16
3179879	1	1	Ballasts	40	0	40	0	40	0	0%	04/12/94	07/01/95	09/01/98	16
3179879	1	1	Ballasts	50	0	50	0	50	0	0%	04/12/94	07/01/95	09/01/98	16
3472876	1	1	Ballasts	16	16	0			0	100%	09/28/95		12/01/97	16
3747470	1	1	Ballasts	72	72	0			0	100%	09/09/94		12/01/97	16
3779326	1	1	Ballasts	30	28	2	2	0	0	100%	06/27/94	09/01/97	12/01/97	16
3855245	1	1	Ballasts	52	52	0			0	100%	12/28/94		12/01/97	16
3885052	1	1	Ballasts	42	42	0			0	100%	12/23/94		12/01/97	16
3906484	1	1	Ballasts	8	7	0			1	88%	12/29/95		12/01/97	16
4008825	1	1	Ballasts	296	295	1	1	0	0	100%	08/25/94	08/15/95	09/01/98	16
4013384	1	1	Ballasts	15	15	0			0	100%	02/09/94		12/01/97	16
4113327	1	1	Ballasts	43	39	2	2	0	2	95%	05/10/94	09/07/97	12/01/97	16
4121207	1	1	Ballasts	3	3	0			0	100%	12/01/94		09/01/98	16
4147678	1	1	Ballasts	6	6	0			0	100%	08/11/95		12/01/97	16
4165965	1	1	Ballasts	76	76	0			0	100%	03/10/95		12/01/97	16
4193320	1	1	Ballasts	50	50	0			0	100%	09/21/95		12/01/97	16
4193320	1	1	Ballasts	108	106	2	2	0	0	100%	09/21/95	10/01/97	12/01/97	16
4268025	1	1	Ballasts	12	12	0			0	100%	01/13/95		12/01/97	16
4268025	1	1	Ballasts	36	26	0			10	72%	06/29/95		12/01/97	16
4302893	1	1	Ballasts	191	186	5	0	5	0	97%	09/27/94	01/01/97	09/01/98	16
4302893	1	1	Ballasts	352	342	5	5	0	5	99%	09/27/94	04/01/95	09/01/98	16
4310774	1	1	Ballasts	10	10	0			0	100%	04/21/94		12/01/97	16
4332790	1	1	Ballasts	39	39	0			0	100%	05/18/94		12/01/97	16
4404297	1	1	Ballasts	29	29	0			0	100%	11/22/94		12/01/97	16
4408311	1	1	Ballasts	272	267	5			0	98%	05/26/94	07/01/97	09/01/98	16
4431822	1	1	Ballasts	1361	1361	0			0	100%	01/27/95		12/01/97	16

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L23 Survival Information

4485679	1	1	Ballasts	18	7	11			0	39%	03/06/95	09/03/98	09/01/98	16
4487096	1	1	Ballasts	21	21	0			0	100%	03/24/94		12/01/97	16
4525621	1	1	Ballasts	1094	1074	20	20	0	0	100%	03/03/94	08/15/94	09/01/98	16
4541246	1	1	Ballasts	4	4	0			0	100%	07/13/95		12/01/97	16
4670202	1	1	Ballasts	39	39	0			0	100%	07/08/94		12/01/97	16
4687838	1	1	Ballasts	395	395	0			0	100%	03/24/94		12/01/97	16
4687838	1	1	Ballasts	395	395	0			0	100%	03/24/94		12/01/97	16
4752377	1	1	Ballasts	16	16	0			0	100%	04/21/94		09/01/98	16
4752377	1	1	Ballasts	84	84	0			0	100%	04/21/94		09/01/98	16
4755000	1	1	Ballasts	13	13	0			0	100%	02/27/95		12/01/97	16
5032685	1	1	Ballasts	47	47	0			0	100%	04/27/95		09/01/98	16
5036687	1	1	Ballasts	10	9	1			0	90%	03/10/95		09/01/98	16
5058685	1	1	Ballasts	10	9	1	0	1	0	90%	10/12/95		09/01/98	16
5303650	1	1	Ballasts	88	88	0			0	100%	12/28/94		09/01/98	16
5346552	1	1	Ballasts	337	319	18	18	0	0	100%	03/06/95	11/15/97	09/01/98	16
5347942	1	1	Ballasts	26	24	2			0	92%	03/30/95	08/15/96	09/01/98	16
5362533	1	1	Ballasts	80	74	6	6	0	0	100%	12/13/95	07/01/97	09/01/98	16
5362533	1	1	Ballasts	80	74	6	6	0	0	100%	12/13/95	07/01/97	09/01/98	16
5368471	1	1	Ballasts	137	137	0			0	100%	05/11/95		12/01/97	16
5412428	1	1	Ballasts	44	44	0			0	100%	08/17/95		12/01/97	16
5494236	1	1	Ballasts	4	4	0			0	100%	03/31/94		12/01/97	16
5494236	1	1	Ballasts	14	14	0			0	100%	03/31/94		12/01/97	16
5494236	1	1	Ballasts	22	22	0			0	100%	03/31/94		12/01/97	16
5528310	1	1	Ballasts	7	7	0			0	100%	12/29/95		12/01/97	16
5538028	1	1	Ballasts	6	6	0			0	100%	03/08/94		12/01/97	16
5557096	1	1	Ballasts	5	5	0			0	100%	08/25/94		09/01/98	16
5614720	1	1	Ballasts	20	19	1	1	0	0	100%	12/13/95	03/13/96	09/01/98	16
5642304	1	1	Ballasts	16	16	0			0	100%	05/02/94		12/01/97	16
5642304	1	1	Ballasts	463	463	0			0	100%	05/02/94		12/01/97	16
5642318	1	1	Ballasts	176	106	2	2	0	68	61%	08/17/95		12/01/97	16
5734112	1	1	Ballasts	25	25	0			0	100%	05/25/95		09/01/98	16
5734112	1	1	Ballasts	40	38	2			0	95%	05/25/95	02/15/98	09/01/98	16
5821704	1	1	Ballasts	26	26	0			0	100%	12/30/94		12/01/97	16
5821704	1	1	Ballasts	30	30	0			0	100%	12/30/94		12/01/97	16

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L23 Survival Information

5832227	1	1	Ballasts	44	40	4	4	0	0	100%	01/24/94	07/01/97	09/01/98	16
5970809	1	1	Ballasts	58	58	0			0	100%	05/06/94		12/01/97	16
6044501	1	1	Ballasts	85	0	85			0	0%	06/08/95		09/01/98	16
6073039	1	1	Ballasts	22	21	1	0	1	0	95%	03/06/95		12/01/97	16
6138311	1	1	Ballasts	54	54	0			0	100%	04/27/95		09/01/98	16
Total	138	138	Ballasts	12085	11545	361	110	125	179	96%				16

Exhibit Attachment 1 - 4

L37 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
938488	1	1	Fixtures	12	11	1	0	1	0	92%	1/24/94	07/15/97	09/01/98	16
1005949	1	1	Fixtures	10	9	1	1	0	0	100%	2/15/94	07/01/94	09/01/98	16
1215824	1	1	Fixtures	6	6	0			0	100%	3/24/94		09/01/98	16
1396689	1	1	Fixtures	7	7	0			0	100%	1/27/94		09/01/98	16
1396689	1	1	Fixtures	17	17	0			0	100%	1/27/94		09/01/98	16
2426908	1	1	Fixtures	6	6	0			0	100%	3/1/94		09/01/98	16
3097112	1	1	Fixtures	4	4	0			0	100%	1/11/94		09/01/98	16
4208161	1	1	Fixtures	12	0	12			0	0%	4/5/94	03/15/98	09/01/98	16
4453004	1	1	Fixtures	14	11	3	0	3	0	79%	4/26/94	06/15/98	09/01/98	16
4622832	1	1	Fixtures	58	58	0			0	100%	3/15/94		09/01/98	16
4846590	1	1	Fixtures	9	9	0			0	100%	3/21/94		09/01/98	16
6074680	1	1	Fixtures	12	12	0			0	100%	1/24/94		09/01/98	16
6109257	1	1	Fixtures	8	8	0			0	100%	2/4/94		09/01/98	16
Total	13	13	Fixtures	175	158	17	1	4	0	91%				16

Exhibit Attachment 1 - 5

L81 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
238198	1	1	Fixtures	4	3	1			0	75%	4/13/95	08/26/98	09/01/98	16
285598	1	1	Fixtures	14	13	1			0	93%	11/7/94	09/15/97	09/01/98	16
285598	1	1	Fixtures	26	24	2			0	92%	11/7/94	09/15/97	09/01/98	16
677006	1	1	Fixtures	80	79	1	0	1	0	99%	12/7/95	03/15/97	09/01/98	16
856513	1	1	Fixtures	26	26	0	0	0	0	100%	3/15/95		12/01/97	16
865139	1	1	Fixtures	48	48	0			0	100%	2/27/95		12/01/97	16
909753	1	1	Fixtures	18	11	7	0	7	0	61%	10/21/94	07/01/97	09/01/98	16
909753	1	1	Fixtures	135	88	20	0	20	27	65%	10/21/94	07/01/97	09/01/98	16
909849	1	1	Fixtures	14	14	0			0	100%	5/6/94		09/01/98	16
910786	1	1	Fixtures	76	76	0			0	100%	2/21/95		09/01/98	16
917606	1	1	Fixtures	18	18	0			0	100%	12/21/94		09/01/98	16
1067517	1	1	Fixtures	14	14	0			0	100%	8/3/95		09/01/98	16
1100538	1	1	Fixtures	3	2	1			0	67%	12/12/94	01/15/98	09/01/98	16
1344033	1	1	Fixtures	9	9	0			0	100%	8/9/94		09/01/98	16
2443532	1	1	Fixtures	7	7	0			0	100%	8/18/94		09/01/98	16
2450622	1	1	Fixtures	7	7	0			0	100%	12/15/94		09/01/98	16
3760006	1	1	Fixtures	30	30	0			0	100%	6/9/94		12/01/97	16
4179969	1	1	Fixtures	6	6	0			0	100%	9/19/94		09/01/98	16
4203117	1	1	Fixtures	18	18	0			0	100%	6/9/94		09/01/98	16
4254160	1	1	Fixtures	8	8	0			0	100%	9/1/94		12/01/97	16
4445999	1	1	Fixtures	16	16	0			0	100%	7/13/95		09/01/98	16
4785908	1	1	Fixtures	28	27	1	0	1	0	96%	7/20/95	09/15/97	09/01/98	16
4882613	1	1	Fixtures	8	8	0			0	100%	6/27/94		09/01/98	16
4915744	1	1	Fixtures	6	6	0			0	100%	9/9/94		12/01/97	16
4915744	1	1	Fixtures	16	16	0			0	100%	12/17/94		12/01/97	16
4927163	1	1	Fixtures	19	19	0			0	100%	5/6/94		09/01/98	16
4951313	1	1	Fixtures	32	32	0			0	100%	5/13/94		12/01/97	16
5245131	1	1	Fixtures	3	3	0			0	100%	2/27/95		09/01/98	16
5247322	1	1	Fixtures	2	2	0			0	100%	12/23/94		09/01/98	16
5303650	1	1	Fixtures	25	24	1			0	96%	12/28/94	09/01/98	09/01/98	16
5370494	1	1	Fixtures	3	3	0			0	100%	1/13/95		09/01/98	16
5431561	1	1	Fixtures	27	27	0			0	100%	10/10/94		12/01/97	16
5796945	1	1	Fixtures	6	6	0			0	100%	11/18/94		09/01/98	16
6045066	1	1	Fixtures	19	19	0			0	100%	6/8/95		09/01/98	16
Total	34	34	Fixtures	771	709	35	0	29	27	92%				16

Exhibit Attachment 1 - 6
S11 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
374147	1	1	Tons	400	400	0			0	100%	12/30/94		12/01/97	20
600137	1	1	Tons	266	266	0			0	100%	12/30/94		09/01/98	20
654873	1	2	Tons	900	900	0			0	100%	02/01/94		09/01/98	20
870019	1	2	Tons	800	800	0			0	100%	08/04/94		12/01/97	20
871500	1	1	Tons	729	729	0			0	100%	04/21/94		12/01/97	20
897852	1	1	Tons	489	489	0			0	100%	08/04/94		09/01/98	20
1042066	1	1	Tons	1250	1250	0			0	100%	11/14/94		09/01/98	20
Total	7	9	Tons	4834	4834	0			0	100%				20

Exhibit Attachment 1 - 7
S15 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
374147	1	1	tons	400	400	0			0	100%	12/30/94		12/01/97	20
600137	1	1	tons	261	261	0			0	100%	12/30/94		09/01/98	20
619404	1	1	tons	93	93	0			0	100%	05/26/94		12/01/97	20
624853	1	1	tons	62	62	0			0	100%	05/26/94		12/01/97	20
636620	1	1	tons	250	250	0			0	100%	05/26/94		12/01/97	20
677011	1	1	tons	679	679	0			0	100%	12/30/94		12/01/97	20
853032	1	1	tons	58	58	0			0	100%	12/30/94		12/01/97	20
854987	1	2	tons	80	80	0			0	100%	12/23/94		12/01/97	20
870019	1	1	tons	914	914	0			0	100%	08/18/94		12/01/97	20
870188	1	1	tons	186	186	0			0	100%	06/21/94		12/01/97	20
871500	1	1	tons	227	227	0			0	100%	06/21/94		12/01/97	20
900212	1	1	tons	333	333	0			0	100%	12/30/94		12/01/97	20
906696	1	1	tons	138	138	0			0	100%	06/21/94		12/01/97	20
934555	1	1	tons	121	121	0			0	100%	05/26/94		12/01/97	20
1042066	1	1	tons	3750	3600	0			150	96%	11/14/94		09/01/98	20
1087447	1	1	tons	58	58	0			0	100%	10/10/94		12/01/97	20
1103530	1	1	tons	243	243	0			0	100%	08/01/94		09/01/98	20
3915107	1	1	tons	768	768	0			0	100%	05/26/94		12/01/97	20
4115905	1	1	tons	440	440	0			0	100%	05/04/95		12/01/97	20
4165636	1	1	tons	187	187	0			0	100%	12/30/94		12/01/97	20
4173605	1	1	tons	100	100	0			0	100%	12/30/94		12/01/97	20
4183829	1	1	tons	100	100	0			0	100%	12/30/94		12/01/97	20
4281196	1	1	tons	100	100	0			0	100%	12/30/94		12/01/97	20
4395331	1	1	tons	473	473	0			0	100%	04/12/94		12/01/97	20
Total	24	25	tons	10022	9871	0	0	0	151	98%				20

Exhibit Attachment 1 - 8
S22 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
1001215	1	2	hp	30	30	0			30	100%	09/12/95		12/01/97	16
1015119	1	3	hp	55	35	0			20	64%	10/19/95		09/01/98	16
1020729	1	1	hp	5	0	5	0	5	0	0%	05/02/94	09/15/95	09/01/98	16
1062055	1	1	hp	10	0	10			0	0%	11/18/94		09/01/98	16
1103604	1	1	hp	15	15	0			0	100%	12/21/94		12/01/97	16
1103604	1	1	hp	25	25	0			0	100%	12/21/94		12/01/97	16
4108727	1	2	hp	80	80	0			0	100%	03/10/95		12/01/97	16
4350526	1	2	hp	50	50	0			0	100%	12/13/95		09/01/98	16
4891950	1	1	hp	7.5	7.5	0			0	100%	12/28/94		09/01/98	16
4891950	1	2	hp	10.5	10.5	0			0	100%	12/28/94		09/01/98	16
4891950	1	2	hp	20	20	0			0	100%	12/28/94		09/01/98	16
5153322	1	2	hp	100	100	0			0	100%	12/30/94		09/01/98	16
5248633	1	3	hp	50	50	0			0	100%	06/23/95		09/01/98	16
5390378	1	1	hp	25	20	0			5	80%	06/08/95		09/01/98	16
5390378	1	3	hp	25	25	0			0	100%	06/08/95		09/01/98	16
5650146	1	2	hp	40	20	0			20	50%	05/19/95		12/01/97	16
Total	16	29	hp	548	488	15	0	5	75	89%				16

Exhibit Attachment 1 - 9
204 Survival Information

Control	Number of Sites	Number of Systems Installed	Units	Retention Qty	Qty in Operation	Qty Failed, Removed, Replaced	Qty Warrantied	Qty w/o Warranty	Qty UTD	Percent Still Good	Install Date	Failure Date	Survey Date	EUL
220840	1	1	Systems	1	1	0			0	100%	06/23/95		12/01/97	14
221218	1	1	Systems	1	1	0			0	100%	05/25/95		12/01/97	14
261837	1	1	Systems	1	1	0			0	100%	06/29/95		09/01/98	14
309237	1	1	Systems	1	1	0			0	100%	08/24/95		12/01/97	14
348858	1	1	Systems	1	1	0			0	100%	03/15/95		12/01/97	14
366775	1	1	Systems	1	1	0			0	100%	06/29/95		12/01/97	14
907236	1	1	Systems	1	1	0			0	100%	12/22/95		09/01/98	14
915179	1	1	Systems	1	1	0			0	100%	09/27/94		12/01/97	14
915723	1	1	Systems	1	1	0			0	100%	12/09/94		12/01/97	14
1001134	1	1	Systems	1	1	0			0	100%	09/28/95		12/01/97	14
1071184	1	1	Systems	1	1	0			0	100%	08/09/94		12/01/97	14
1077218	1	1	Systems	1	1	0			0	100%	12/29/95		09/01/98	14
1098922	1	1	Systems	1	1	0			0	100%	11/03/94		09/01/98	14
3156991	1	1	Systems	1	1	0			0	100%	11/18/94		09/01/98	14
3824814	1	1	Systems	1	1	0			0	100%	03/15/95		09/01/98	14
4466281	1	1	Systems	1	1	0			0	100%	12/06/94		12/01/97	14
4552195	1	1	Systems	1	1	0			0	100%	02/09/95		09/01/98	14
4586202	1	1	Systems	1	1	0			0	100%	08/12/94		12/01/97	14
4695865	1	1	Systems	1	1	0			0	100%	12/20/95		09/01/98	14
4851341	1	1	Systems	1	0	1			0	0%	06/03/94	08/01/98	12/01/97	14
5044885	1	1	Systems	1	1	0			0	100%	11/03/94		12/01/97	14
Total	21	21	Systems	21	20	1	0	0	0	95%				14

Attachment 2

Sample Design Memos Submitted to the CADMAC Subcommittee on Persistence

RLW Statistical Methodology

Task 3: Sample Design

Background

Our preliminary calculation of the required sample size was based on the hypothesis-testing approach described in the RFP, following the proposed changes to the Protocols. The null hypothesis is that the ex-anti estimates of measure life still reflect the current population. For this purpose, the ex-anti estimate of measure life will be calculated as a weighted average of the individual measure lives, using the net resource benefit as the weights applied to each category of measure.

The ex-anti estimates will be changed only if there is a significant difference between the ex-post and ex-anti estimates of measure life at the 80% level of confidence. Unless agreed otherwise, a two-sided test will be used. We have assumed that the sample size should be chosen so that the hypothesis test should have 80% probability of rejecting the null hypothesis under the assumption that the true value is 20% less than the ex-anti estimate.

We found that the preceding criterion requires a sample of 28 sites. We chose to apply this criterion to each of the two program years. Our sample size planning was carried out in the following five steps:

1. Establish the procedure for estimating the survival proportion S of the measures in a set of buildings of a particular average age t. Specifically, consider a particular program year such as PY94 and assume an exponential survival function as specified in the RFP.

2. Establish the procedure for estimating the effective useful life EUL for a particular set of buildings, given an estimate of the survival proportion S.

3. Find the relationship between the sampling distributions for estimating survival and for estimating effective useful life. In particular, how is the coefficient of variation (cv) of the estimator of EUL related to the coefficient of variation of the estimator of S?

4. Find the required value of the coefficient of variation of the estimator of EUL to satisfy the hypothesis-testing framework of the proposed protocols.

5. Find the relationship between the required sample size n and the coefficient of variation of the estimator of EUL. Solve for the sample size n.

The results of steps 1 and 2 are discussed under Task 9 – Analyze Data.

For each of the two program years, we will define the survival proportion S to be the current energy use of the corresponding population of program participants as a proportion of the gross first year savings found in the program evaluation. We will use standard MBSS™ ratio estimation techniques to estimate S from the information from the telephone and onsite surveys and the corresponding engineering models. This estimator may be denoted $\hat{S}$. The MBSS procedure will give the value of $\hat{S}$ and the corresponding standard error. We will also determine the savings-weighted average age of the buildings, denoted *t*.

The next step in our analysis was to obtain an estimate of EUL from $\hat{S}$. Following the exponential failure model and the definition of EUL from the RFP, we will use the estimator

$$E\hat{U}L = \frac{t\ \ln(.5)}{\ln(\hat{S})}$$

The third step was to find the relationship between the sampling distributions for estimating survival and for estimating effective useful life. Using a standard tailor's series expansion of the preceding equation, we found that the coefficient of variation of $E\hat{U}L = \frac{t\ \ln(.5)}{\ln(\hat{S})}$ is approximately equal to the coefficient of variation of $\hat{S}$ itself.

The fourth step was to find the coefficient of variation (*cv)* of the estimator of *EUL* to satisfy the hypothesis-testing framework of the proposed protocols. Using the Central Limit Theorem, we assumed that $E\hat{U}L$ is normally distributed with unknown expected value μ and standard deviation σ. We specified the null hypothesis $H_0 : \mu = \mu_0$ based on the ex anti estimate of measure life. The decision rule was to reject the null hypothesis if $|z| > z_0 = 1.28$ where z is the usual test statistic. Assuming that $\mu = \mu_1 = 0.8\,\mu_0$, we want the probability of rejecting the null hypothesis to be 0.8. From the normal distribution we defined $z_1 = 0.84$ and determined the design equation satisfying the preceding requirement:

$$.8\,\mu_0 + z_1\,\sigma = \mu_0 - z_0\,\sigma$$

This can be rewritten as

$$cv = \frac{\sigma}{\mu_0} = \frac{.2}{z_0 + z_1} = .0943$$

This implies that the study will satisfy the protocols if the coefficient of variation of the estimator of the EUL is equal to .0943.

The final task was to determine the relationship between the required sample size *n* and the desired coefficient of variation and then to solve for the sample size *n*. For this purpose we assumed that each site satisfies a binary failure model. We assumed that the current savings of each site was either the measured first-year saving, with probability *p* = 0.8, or zero otherwise. Under MBSS analysis, it can be shown that if each site is selected with probability proportional to savings, then the coefficient of variation of the estimated survival is approximately

$$cv = \sqrt{\frac{1-p}{np}} = \sqrt{\frac{1}{4n}}$$

From step 2, this is also the coefficient of variation of the estimated EUL. Solving the preceding two equations, we found n = 28.

Ridge & Associates

Memo

To: Valerie Richardson

From: Richard Ridge

CC: Mike Baker, John Cavalli, Tim Caulfield, Roger Wright,

Date: 01/29/99

Re: Retention Methods

Per our agreement at the kickoff meeting on 7/21/98, I have determined the various approaches that different contractors are planing to use to estimate effective useful lives (EULs). I have focused on the differences among PG&E contractors and across contractors for PG&E's and SCE's commercial new construction retention studies. In addition, I have estimated the number of failures that we need to see in the sample of 150 sites in order to achieve the Protocol-required level of precision.

Differences Across Consultants

I have spoken with John Cavalli of Quantum and Tim Caulfield of Equipoise in order to determine how they are approaching the estimation of EULs. John Cavalli also indicated that Lisa Skumatz is using the same techniques as Quantum. There appear to be four basic approaches. The first is what I call classic survival analysis (CSA) which involves the analysis of data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end-point (Collett, 1994). Regression refers to the familiar estimation of an ordinary least squares (OLS) regression that estimates the relationship between time and the percent of savings remaining at a site or the percent of equipment still present and operable (Maddala, 1992). The third approach involves assuming a function form (AFF) such as the logistic or exponential, conducting a survey at a given point in time after the installation, and using the data in conjunction with the adopted functional form to estimate the EUL. A fourth technique, time series, refers to an analysis of a single variable over time. Such methods include Box-Jenkins and exponential smoothing (Goodrich, 1992).

In Table 1, I indicate that a consultant is using one of these four approaches by placing an "X" in a cell.

Table 1. Analysis Techniques by Proposed by PG&E Consultants

	SBW	Quantum	Equipoise	Skumatz	RLW
CSA	X	X		X	
OLS		X	X		
AFF					X
Time Series					

Table 1 provides some useful information. First, one can see that there is a fair amount of consistency across the PG&E consultants with three of the four planning to use the CSA approach. The primary reason why I, and presumably the other two PG&E consultants, have chosen the CSA approach is that it is specifically designed to address problems having to do with persistence and retention. Also, using CSA, one can test various functional forms rather than assuming one. Note that Equipoise, using the OLS approach, is not assuming a functional form either. Second, only Quantum has specifically listed a backup method if the CSA approach does not perform well. However, I, and presumably the other two PG&E consultants, are prepared to try other approaches if our primary approach fails. Third, with respect to SCE's Commercial New Construction Retention Study, RLW will be using the AFF approach. Having reviewed the various methods proposed by me and the other consultants, I want to emphasize that all of the methodological choices are legitimate, are within the spirit of the Protocols, and are based on their expectations regarding the quantity and quality of the data that are available.

As we all know, aside from the reporting requirements in Tables 6 and 7, the Protocols have virtually nothing to say about retention study issues such as sample sizes, the kinds of statistical models that should be used, and the size of the difference between the *ex ante* EUL and the *ex post* EUL that our statistical models should be designed to detect. The Protocols only state that the confidence level should be set at 80 percent. This provides utilities with a fair amount of latitude.

Required Samples Sizes

For the PG&E Commercial New Construction Retention Study, I have attempted to estimate the number of failures required for the CSA approach to achieve the required level of precision. To perform this calculation, one must make a number of other assumptions in addition to the confidence level. For example, how big a difference between the *ex ante* and the *ex post* EULs (the so-called effect size) should the statistical test be able to detect as significant?[1] This is a particularly critical factor since the sample size is to a large extent a function of the effect size. Assuming a large effect size allows one to reduce the sample size accordingly. Because, the Protocols say nothing about effect size, utilities have a fair amount

[1] The effect size, the size of the sample, and the confidence level can be used to determine the *power* of the test (Cohen, 1988). Alternatively, the desired power of the test, the expected effect size, and the confidence level can be used to determine the size of the sample.

of latitude regarding the size of their retention samples. Simply setting the desired level of confidence at 80 percent does not lead one to the desired sample size.

For our purposes, I have assumed a logistic functional form, a power[2] of .8, an alpha of .20 (i.e., 80 percent confidence level), an *ex ante* EUL of 16 years, and an expected difference between the *ex ante* and *ex post* EULs set first at 20 percent and then at 30 percent (i.e., the savings expected to survive until the 16th year were set at 26 percent and 17 percent respectively). At an effect size of 20 percent, the required number of failures is 24 while at an effect size of 30 percent the required number of failures is 17 (recall that the larger the effect the smaller the required number of failures). Note that RLW chose the 20 percent effect size and a power of .8, both of which are reasonable. However, the Protocols do not prohibit assuming a larger effect size or a lower power.

While we plan to survey 150 sites, we are assuming, for this calculation, that we will actually visit no more than 30 sites. Lets also assume that the kWh savings at each site can be divided into ten bundles bringing the total number of bundles to 300 (10 x 30). If we choose an effect size of 20 percent, we must observe failures in at least 24 or 8 percent of the 300 bundles. If we chose an effect size of 30 percent, we must observe failures in at least 17 bundles or 5.7 percent. At this time, both of these numbers (24 and 17) seem like reasonable expectations.

If the number of expected bundle failures is not observed during the on sites, we will adopt one of the alternative methods described earlier.

References

1. D. Collett. *Modeling Survival Data in Medical Research.* New York: Chapman & Hall, 1994.

2. Maddala, G. S. *Introduction to Econometrics*. Englewood Cliffs, NJ: Prentice Hall, 1992.

3. Goodrich, Robert L. *Applied Statistical Forecasting*. Belmont, MA: Business Forecast Systems, 1992.

[2] The power of a statistical test of a null hypothesis is defined as the probability that it will lead to a rejection of the null hypothesis when it is false.

Attachment 3

Protocol Tables 6 and 7

PROTOCOL TABLES 6B AND 7B

FOURTH YEAR RETENTION STUDY FOR THE 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES

PG&E STUDY ID #s 324R1 & 326R1

This Attachment presents Tables 6B and 7B for the above referenced study as required under the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols), as adopted by the California Public Utility Commission (CPUC) Decision 93-05-063, Revised March 1998 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

Table 6B Notes

Item 2: Both the MDSS and PG&E Advice Filing were used as sources for the ex ante EUL. The EMS, 204 measure, however, was found to have various measure lives in the MDSS, ranging from 10 to 20 years (with one customer having a measure life of 1.25 years.) Over two-thirds of the customers had a measure life of 14 years, and the mean measure life was 14.1 years. Therefore, we used 14 years as the ex ante measure life for EMS, measure 204.

Items 3, 5 and 6: There were not a sufficient number of failures or removals in observed in the retention data to support a study result for the L19, 204, S11 or S15 measures.

The Table 7B synopsis of analytical methods applied follows Protocol Table 6B.

Protocol Table 6.B
Results of Retention Study
PG&E 1995 Commercial Energy Efficiency Incentives Program
Study ID #s 324R1 & 326R1

Item 1			Item 2		Item 3	Item 4	Item 5	Item 6		Item 7	Item 8	Item 9
PG&E Measure Code	**Studied Measure Description**	**End Use**	**Ex Ante EUL**	**Source of Ex Ante EUL**	**Ex post EUL from Study**	**Ex Post EUL to be used in Claim**	**Ex Post EUL Standard Error**	**80% Conf. Interval Lower Bound**	**80% Conf. Interval Upper Bound**	**p-Value for Ex Post EUL**	**EUL Realizat'n Rate (ex post/ex ante)**	**"Like" Measures Associated with Studied Measure (by measure code)**
L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	Lighting	16	Advice Filing & MDSS	-	16	-	-	-	-	100%	L17, L18, L20, L76 - L77
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	Lighting	16	Advice Filing & MDSS	20	16	8	10	30	0.01	100%	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	Lighting	16	Advice Filing & MDSS	11	16	6	4	18	0.06	100%	L25, L78 - L80, L26, L27
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	Lighting	16	Advice Filing & MDSS	11	16	6	4	18	0.06	100%	L25, L78 - L80, L26, L27
204	INSTALL HVAC EMS	HVAC	14	Advice Filing & MDSS	-	14	-	-	-	-	100%	-
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	HVAC	20	Advice Filing & MDSS	-	20	-	-	-	-	100%	S9, S10, S12, S13, S16
S15	COOLING TOWER	HVAC	20	Advice Filing & MDSS	-	20	-	-	-	-	100%	-
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	HVAC	16	Advice Filing & MDSS	18	16	12	3	34	0.13	100%	-

PROTOCOL TABLE 7B

1995 COMMERCIAL EEI PROGRAM
FOURTH YEAR RETENTION STUDY
PG&E STUDY ID #324R1 AND #326R1

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7B of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). The major topics covered in this section are organized and presented in the same order as they are listed in Table 7B for ease of reference and review. For items discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

1. OVERVIEW INFORMATION

A. Study Title and Study ID Number

Study Title: Fourth Year Retention Study of PG&E's 1995 Commercial EEI Program.

Study ID Numbers: 324R1 and 326R1

B. Program, Program Year and Program Description

Program: PG&E Commercial EEI Program.

Program Year: Rebates Received in the 1995 Calendar Year.

Program Description:

The Commercial Energy Efficiency Incentives Program for lighting and HVAC technologies offered by PG&E has three components: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) Program and the Customized Incentives (CI) Program.

The RE Program

The RE program offered fixed rebates to customers who installed specific electric energy-efficient equipment. The program covered the most common energy saving measures and spans lighting, air conditioning, refrigeration, motors, and food service. Customers were required to submit proof of purchase with these applications in order to receive rebates. The program was marketed to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

The REO Program

The REO program targeted commercial, industrial, agricultural, and multi-family market segments most likely to benefit from these selected measures. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated amongst PG&E's divisions, emphasizing local planning areas with high marginal electric costs to maximum the program's benefits.

The Customized Incentives Program

The Customized Incentives program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. These customers were required to submit calculations for projected first-year energy impacts with their applications prior to installation of the project. The maximum incentive amount for the Customized Incentives program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50 percent of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

Due to the significant documentation and analysis involved in Customized Incentives program measures, however, rebates for a number of 1992, 1993 and 1994 measures were delayed for payment until 1995. This evaluation covers those measures where rebates were paid in 1995.

As a result of program design, the measures installed were similar to or the same as those for the RE program, but were installed in larger and more complex projects.

C. *End Uses and/or Measures Covered*

End Use Covered: Indoor Lighting and HVAC Technologies.

Measures Covered: For the list of measures covered in this evaluation, see *Exhibit* 2-3.

D. *Methods and Models Used*

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data. For some measures, it was sufficient to only look at the raw data, because for some measures, all of the sampled equipment was still in place and operable.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, we constructed an empirical survival function.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. We have modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

The details surrounding each of these steps is provided in *Section 3*.

E. Analysis Sample Size

Exhibit 3-2 provides the final sample disposition used in the study analysis.

2. DATABASE MANAGEMENT

A. Key Data Elements and Sources

The original retention panels and the follow-up survey data were the only data sources used for this analysis.

B. Data Attrition Process

All data points that had follow-up survey data were utilized in the analysis. As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure/removal dates were not obtainable.

C. Internal Data Quality Procedures

The Evaluation contractor of this project, Quantum Consulting Inc. (QC), has performed extensive data quality control on all retention and follow-up survey data. QC's data quality procedures are consistent with PG&E's internal database guidelines and the guidelines established in the Protocols.

Throughout every step of this project, numerous data quality assurance procedures were in place to ensure that all data used in analysis and all survey data collected was of the highest quality. All data entry was performed using blind double-key data entry. On questionable responses follow-up phone calls or site visits were made.

D. Unused Data Elements

Without exception, all data collected specifically for the Evaluation were utilized in the analysis.

3. *SAMPLING*

A. *Sampling Procedures and Protocols*

Section 3.1 describes the sample procedures and protocols.

B. *Survey Information*

The data collection instrument is presented in the *Attachment 3*. *Attachment 1* contains the raw data collected for each site surveyed, by measure. *Exhibit 3-2* provides the final sample disposition, which contains the number of sites and units that were in the sample frame, and the number surveyed.

C. *Statistical Descriptions*

As mentioned above, a complete set of participant responses are presented in *Attachment 1*. In addition, statistics variables that were used in the survival models are also presented in *Section 3*.

4. *DATA SCREENING AND ANALYSIS*

A. *Procedures for Treating Outliers and Missing Data*

All data points that had follow-up survey data were utilized in the analysis. As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure/removal dates were not obtainable.

B. *Background Variables*

Due to the nature of this analysis (survival analysis), background variables, such as interest rates, unemployment rates and other economic factors, were not considered to be a necessary component of the analysis.

C. *Data Screen Process*

Again, all data points that had follow-up survey data were utilized in the analysis.

D. *Regression Statistics*

The regression statistics for the models implemented are provided in *Section 3*.

E. *Model Specification*

The model specifications are presented in *Section 3*.

F. Measurement Errors

For the survival analysis, the main source of measurement errors is the survey data. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we implemented several controls to reduce systematic bias in the data. These steps include: (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the survival analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

G. Influential Data Points

No diagnostics were used to identify outliers.

H. Missing Data

As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure/removal dates were missing. There were no other missing data points, other than failure/removal dates.

I. Precision

The SAS output provided the standard errors for the 50^{th} percentile (or median). Because the analysis was conducted on the unit of measure (e.g., a ballast) and not a site, the standard errors from SAS were grossly underestimated. SAS treats each observation in the dataset as independent. However, it is likely that there is significant correlation in the observations that are common to a single site (especially in the event that a removal occurs.) For example, when a removal occurs, it is likely that many measures are removed at once. To a lesser extent, failures are correlated since they may all come from the same manufacturing lot, they are all likely to be installed under the same circumstances, and they are also used in a similar manner.

If we believed that there was 100 percent correlation of failure/removal for all measures with a site, we could simply multiply the standard error calculated from SAS by the square root of the ratio of the number of units to sites. Therefore, if there were an average of 100 units installed per measure, we would multiply by 10.

We felt, however, that there were two components to our error: one caused by variation across sites, and another caused by variation across measures. The errors calculated by SAS correspond only to the error across measures.

To estimate the standard error associated with failures and removals, we first took the SAS output and backed out a standard deviation. This was achieved by multiplying the standard error from SAS by the square root of the sample size (in units.) We then assumed that this standard deviation was associated with the joint probability density function of failures and removals.

(1) $StdErr_{SAS} * \sqrt{N_{Units}} = StdDev_{Failures,\mathrm{Re}\,movals}$

Where,

$StdErr_{SAS}$ is the standard error around the median EUL projected with the SAS System;

$\sqrt{N_{Units}}$ is the square root of the number of sites that contributed to the regression model;

$StdDev_{Failures,\mathrm{Re}\,movals}$ is the standard deviation associated with the median EUL of failures and removals.

We then assumed that failures were independent of removals (Which is of course not true, since a high failure rate may cause a customer to decide to make removal. But we felt this was reasonable overall.) Therefore, the variance of removals and failures is equal to the variance of removals plus the variance of failures:

(2)
$$\begin{aligned} StdDev_{Failures,\mathrm{Re}\,movals}{}^{2} &= Var_{Failures,\mathrm{Re}\,movals} \\ &= Var_{Failures} + Var_{\mathrm{Re}\,movals} \end{aligned}$$

Where,

$StdDev_{Failures,\mathrm{Re}\,movals}{}^{2}$ is the square of the standard deviation associated with the median EUL of failures and removals;

$Var_{Failures,\mathrm{Re}\,movals}$ is the variance which is equivalent to the square of the standard deviation.

If we assume that failures are independent across units, and removals are independent across sites, then the standard error can be calculated as:

$$(3)\quad \begin{aligned} StdErr_{Failures,Removals} &= \sqrt{StdErr_{Failures}^{\ 2} + StdErr_{Removals}^{\ 2}} \\ &= \sqrt{\frac{Var_{Failures}}{N_{Units}} + \frac{Var_{Removals}}{N_{Sites}}} \end{aligned}$$

Where,

$StdErr_{Failures,Removals}$ is the standard deviation associated with the median EUL of failures and removals;

N_{Units} is the number of units used for the regression models;

N_{Sites} is the total number of sites having those units.

Furthermore, if we assume that the underlying standard deviation of failures and removals are equivalent, then:

$$(4)\quad \begin{aligned} StdDev_{Failures,Removals}^{\ 2} &= Var_{Failures,Removals} \\ &= Var_{Failures} + Var_{Removals} \\ &= 2Var_{Failures,or\ Removals} \end{aligned}$$

So,

$$(5)\quad \begin{aligned} Var_{Failures,or\ Removals} &= 0.5 * (StdDev_{Failures,Removals})^2 \\ &= 0.5 * (StdErr_{SAS})^2 * N_{Units} \end{aligned}$$

Therefore, substituting equation (5) in equation (3), we get

$$(6)\quad \begin{aligned} StdErr_{Failures,Removals} &= \sqrt{\frac{0.5 * (StdErr_{SAS})^2 * N_{Units}}{N_{Units}} + \frac{0.5 * (StdErr_{SAS})^2 * N_{Units}}{N_{Sites}}} \\ &= StdErr_{SAS} * \sqrt{0.5 + 0.5 * \frac{N_{Units}}{N_{Sites}}} \end{aligned}$$

It is interesting to note that if there was only one unit per site, the standard error would equal the standard error calculated in SAS. Our resulting standard error is somewhere between the standard error found in SAS, and the standard error from SAS multiplied by the square root of the ratio of the number of units to sites (the method discussed as the beginning of this section.)

Skinner and Kish[1] both offer a more theoretical approach to solving the problem of estimating a standard error when the data are not identical and independently distributed (IID). They define this problem as a design effect, which is the case when the sample is not a simple random sample that is IID, but rather is a cluster sample such as ours. In our case, each site contains a cluster of sample points.

Skinner developed a design effect factor, Deff, that can be used to adjust the standard error obtained from SAS to estimate the true standard error:

$$(7)\quad Deff = \frac{StdErr_{TRUE}^{\;2}}{StdErr_{SAS}^{\;2}}$$

Where,

$StdErr_{TRUE}$ is the actual standard error associated with the median EUL;

$StdErr_{SAS}$ is the standard error associated with the median EUL obtained from SAS;

Skinner estimated the design effect factor as:

$$(8)\quad Deff = 1 + (n-1) * \tau$$

Where,

n = the average number of sample points per cluster (or, in our case, per site)

$$= \frac{N_{Units}}{N_{Sites}}$$

τ = the intra-cluster correlation

[1] Skinner, C. J., "Analysis of Complex Surveys," John Wiley & Sons, 1989, pp. 23-46.
Kish, L., "Survey Sampling," John Wiley & Sons, 1965, pp. 162.

Skinner's design effect factor can be compare directly to the factor we developed in equation (6):

$$(9)\quad Deff(Eq.6) = 0.5 + 0.5 * (\frac{N_{Units}}{N_{Sites}}) = 1 + (n-1) * 0.5$$

Our method discussed above is identical to that developed by Skinner, with an intra-cluster correlation equal to 0.5. As discussed above, we believe that there are two types of events: removals and failures. Our assumption above was that removals are perfectly correlated and failures are totally uncorrelated. Therefore, an intra-cluster correlation of 0.5 is not unreasonable.

To calculate the intra-cluster correlation, it would require knowing the time of failure or removal for all units in our analysis. The intra-cluster correlation measures how correlated the failure/removal times are across all units within a site. Because our analysis is being conducted in such an early stage of the measures life, it is not possible to accurately estimate the correlation. However, given that (1) it is likely that removals are highly correlated, and failures are relatively uncorrelated; and (2) removals are expected to be as prevalent as failures over the life of the measure; then an intra-cluster correlation of 0.5 is a reasonable approximation.

Finally, relative precision estimated at the 80 percent confidence interval was calculated using the following equation:

$$RP = \frac{1.282 * StdErr}{EUL}$$

Where,

$StdErr$ = the standard error calculated using Equation 6, above.

Attachment 4

Survival Data Collection Instrument

Contact Name:

Contact Number:

Company Name:

STRATA: #Error

QC Site ID

- Phone
- OnSite

Actual Name:

Actual Number:

Site Address:

Site City, Zip:

Count As Complete?

- Yes
- No

Measure Code: **Measure Description:**

Make 1 **Make 2**

Model 1 **Model 2**

Retention Quantity: **Quantity Units:**

Technology/ Location Description

Qty in Operation **Given Units** **Alternative Units**

Printed Response re: Equipment Verification

Qty Failed, Removed or Replace **Given Units** **Alternative Units**

UTD = Unable to determine
NA=not applicable

Qty Failed **Est. Date Failed**

UTD = Unable to determine
NA=not applicable

(mm/dd/yy)

Description of Failure (check one)

- 1 = Manufacturing defect
- 2 = Improper Installation
- 3 = Improper Maintenanc
- 4 = Accident/human error
- 5 = Other (Print Reason)
- 99 = Unable to determine

Failure +/or Other comments

Qty Removed **Est. Date Remove**

UTD = Unable to determine
NA=not applicable

(mm/dd/yy)

Reason for Removal (check one)

- 1 = Unsatisfactory Performance
- 2 = Savings not worth the effort
- 3 = Remodeling disabled the installation
- 4 = Type of business changed
- 5 = Moved
- 6 = Equipment Upgraded
- 7 = Other (Print Reason)
- 99 = Unable to determine

Removal +/or Other comments

Qty Replaced **Est. Date Replaced**

UTD = Unable to determine
NA=not applicable

(mm/dd/yy)

Reason for Replacement (check one)

- 1 = Unsatisfactory Performance
- 2 = Savings not worth the effort
- 3 = Remodeling disabled the installation
- 4 = Type of business changed
- 5 = Moved
- 6 = Equipment Upgraded
- 7 = Other (Print Reason)
- 99 = Unable to determine

Replacement +/or Other comments

Replaced w/ Equivalent Technology? (check one)

- 1: Higher Efficiency
- 2: Equivalent Efficiency
- 3: Base line Efficiency
- 4: Other or UTD

Record Replacement Tech

Contact Name:
Contact Number
Actual Name:
Actual Number:

Company Name:
Site Address:
Site City, Zip:

STRATA

QC Site ID:
☐ Phone ☐ OnSite

Count As Complete?
☐ Yes ☐ No

Measure Code **Measure Description** **Tech Type** **Watts/ Lamp** **Lamps/ Fixture**

Retention Quantity: **Quantity Units** **Location Description**

Qty in Operation **Given Units** **Alternative Units**

Printed Response re: Equipment Verification

Qty BALLASTS Failed, Removed or Replaced
UTD = Unable to determine
NA=not applicable

#Lamps/ Ballast **Total # of Ballasts**

 # BALLASTS Failed
UTD = Unable to determine
NA=not applicable

Est. Date Failed
(mm/dd/yy)

Description of Failure (check one)
☐ 1 = Manufacturing defect
☐ 2 = Improper Installation
☐ 3 = Improper Maintenance
☐ 4 = Accident/human error
☐ 5 = Other (Print Reason)
☐ 99 = Unable to determine

Failure +/or Other comments

 # BALLASTS Removed
UTD = Unable to determine
NA=not applicable

Est. Date Removed
(mm/dd/yy)

Reason for Removal (check one)
☐ 1 = Unsatisfactory Performance
☐ 2 = Savings not worth the effort
☐ 3 = Remodeling disabled the installation
☐ 4 = Type of business changed
☐ 5 = Moved
☐ 6 = Equipment Upgraded
☐ 7 = Other (Print Reason)
☐ 99 = Unable to determine

Removal +/or Other comments

 # BALLASTS Replaced
UTD = Unable to determine
NA=not applicable

Est. Date Replaced
(mm/dd/yy)

Reason for Replacement (check one)
☐ 1 = Unsatisfactory Performance
☐ 2 = Savings not worth the effort
☐ 3 = Remodeling disabled the installation
☐ 4 = Type of business changed
☐ 5 = Moved
☐ 6 = Equipment Upgraded
☐ 7 = Other (Print Reason)
☐ 99 = Unable to determine

Replacement +/or Other comments

Replaced w/ Equivalent Technology? (Check one)
☐ 1: Higher Efficiency ☐ 2: Equivalent Efficiency ☐ 3: Base line Efficiency ☐ 4: Other or UTD

Record Replacement Tech

Attachment 5

Retroactive Waiver

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
COMPANY WIDE MODIFICATION TO THIRD AND FOURTH EARNINGS
CLAIM CALCULATION METHODOLOGY

Study ID: All study IDs for all PG&E programs.
Date Approved: February 17, 1999

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[1] by PG&E for the third earnings claim methodology for PG&E's 1994 programs and for all future third and fourth earnings claims. The Protocols, as written, require that all third and fourth earnings claim impacts be calculated as the sum of the measure level AEAP values as adjusted by appropriate ex post Technical Degradation Factors (TDF) and Effective Useful Life (EUL) values. Since all PG&E second earnings claim AEAP amounts are agreed at the end use level, PG&E does not have the measure level AEAP values. PG&E seeks approval to use the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the third and fourth earnings claims.

Proposed Waiver (see Table A for Summary)

PG&E seeks CADMAC approval to:

Use the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net for the third and fourth earnings claims.

Parameters and Protocol Requirements

Table 10, item A.3.b.1 and 2, and A.4.a. and b., require the Resource Benefits, Net to be calculated at the measure level, then summed, using the net load impacts as "determined in the second earnings claim AEAP."

Rationale

The Protocols, as written, require that all third and fourth earnings claim impacts are calculated as the sum of the measure level second earnings claims AEAP values as adjusted by appropriate ex post TDFs and EULs. Since all PG&E second earnings claim AEAP amounts are agreed at the end use level, PG&E does not have the measure level second earnings claim AEAP values required by the methodology. PG&E cannot "back calculate" measure specific level AEAP values since there is no clear information on how to "allocate" the end use level AEAP values to the individual measures. PG&E can, however, use the measure level information from the first year evaluations to proportionally allocate or prorate the end use level AEAP values into estimates of the measure level AEAP values. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net, for the third and fourth earnings claims.

[1] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs.

Conclusion

PG&E is seeking a retroactive waiver to clearly define, in advance, acceptable methods for calculating third and fourth earnings claims. The AEAP process results in AEAP values which cannot be used to estimate the third and fourth earnings claims as required by the Protocols. PG&E's waiver proposes a straightforward alternative that fulfills the spirit of the Protocols.

TABLE A

TABLE 10, EARNINGS DISTRIBUTION SCHEDULE			
Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
Calculation Methodology for Third and Fourth Earnings Claim.	Sum the product of measure level second earnings claim AEAP, ex post TDF, and ex post EULs.	Allow the use of the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be multiplied by the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net for the third and fourth earnings claims.	The AEAP results in end use level AEAP values. The proposed method makes maximum use of evaluation findings to allocate the end use level AEAP values to the measure level. Allocation to the measure level allows both third and fourth earnings claims to be calculated as specified in the Protocols.