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**OWNERSHIP COSTS OF TRAFFIC SIGNAL LAMPS**

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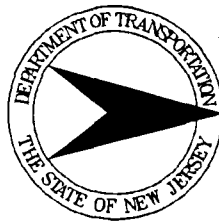
**FINAL REPORT**

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16. Abstract Ownership costs are determined for standard, krypton watt-saver and krypton thermistor traffic signal lamps by evaluating installations at intersections in New Jersey and the monitoring the burnouts. Lamps from six manufacturers for both eight and twelve-inch signal faces were included in a three year test. The lamps were further characterized by four voltage ranges, six wattage ranges, two age groups and three filament support groups. Individual lamp traceability was maintained through lamp numbers, intersection installation sheets and burnout sheets. The accumulated percent burnouts for the lamps are given by "Days Installed," or "Total Average On-Hours Installed," or "Total Average Cycles." With the exception of the two figures in the body of the report, all data and figures are in the twelve appendices.  Ownership costs - the cost to purchase one thousand lamps and to replace the burnouts per one thousand lamps - were determined for six thousand and eight thousand total average on-hours installed.					
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Mr. Dick Uth, Electrical Supervisor Region IV, followed the project on a daily basis through his electrical mechanics and on site visits. He suggested that the old versus new lamps from Sylvania and Westinghouse be included in the evaluation.

The electrical mechanics in Region IV contributed significantly to this project. They were dedicated in installing the lamps, filling out the installation sheets, monitoring the lamps, filling out the burnout and removal sheets and assuring that all of these were returned over to Research during the four years of the two tests.

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Last but not least, is Mr. Joseph Flesch. He started on this project when it was in the proposal stage. His untireless efforts in obtaining lamps, numbering each lamp on the base of the lamp, repackaging lamps, visiting all of the intersections and judging them for inclusion in the project, sketching of each of the selected intersections for inclusion in the project, collecting various sets of data on each of these items, monitoring reasons for removal for each lamp, keeping project records, starting the mainframe lamp data base, and interacting with Region IV personnel, contributed significantly to this project. He laid the foundation for a successful project.

This report is dedicated to the memory of Mr. Joseph Flesch, who was a fine associate.

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## SUMMARY

A field test of various traffic signal lamps was performed to determine measured lamp lifetimes under actual field conditions. Lamp lifetimes are required to find traffic signal lamps with the lowest ownership cost to the State. Ownership cost is dependent on not only the purchase price, but also the maintenance cost of replacing burned out lamps and the cost of electrical energy consumption.

Two field tests were conducted in Region IV, the southern region of the state. The first test consisted of installing 2,040 traffic signal lamps at 76 intersections throughout the Region and monitoring burnouts for three years. A one (1) year test to confirm the results of the first test was subsequently performed.

Lamps from six (6) different manufacturers, Chatham Engineering, Duro-Test, General Electric, Luxor, Sylvania, and Westinghouse were included in the test. Three (3) lamp types, standard, krypton watt-saver and krypton thermistor were included in the test. Lamps were installed in both eight-inch (8") and twelve-inch (12") traffic signal faces. The lamps were further characterized by four (4) voltage ranges, six (6) power ranges, two (2) shelf life age groups and three (3) filament support groups.

Lamps were randomly installed at intersections in the red, amber and green signal faces and pertinent data was recorded on installation sheets. Annual relamping was not performed at the

intersections included in the test. As the test lamps burned out electrical maintenances forces recorded pertinent data on burnout sheets. All data was entered into a computer data base for analysis.

Results of the data analysis are contained in Appendix 11 in graphical form. For the various lamp types plots of "Accumulated Percent Burnouts" versus "Days Installed", "Total Average On-Hours Installed" and "Total Average Cycles" are included in Figures 1 to 28.

Ownership costs per 1,000 lamps for the various lamp types were calculated assuming a cost of \$50 to replace a burned out lamp and a variable lamp purchase price of \$0.20 to \$5.00. Results are plotted in Appendix 11, Figures 29 and 30.

## CONCLUSIONS

- o Krypton watt-saver lamps for twelve-inch signal faces have the lowest ownership costs.
- o Standard lamps for eight-inch signal faces have the next lowest ownership costs.
- o A traffic signal lamp specification requiring quality control checks, inspections, and referencing ownership costs from the last quantity of 60,000 lamps installed is a way of purchasing lamps with improved installed field lifetimes. This process will allow for lamps from manufacturers with improved but more expensive lamps to be purchased. The primary objective is to purchase the lamp with the lowest ownership cost, not necessarily with the lowest purchase price.
- o The installed lifetime of a traffic signal lamp is determined by the total average on-hours provided traffic and wind induced shock and vibration are minimum and manufacturing defects are not present.
- o Group relamping can be the most economical method of replacing traffic signal lamps provided predicted total average on-hours is used to determine the relamping schedule.

- o Traffic signal lamps behind yellow signal faces should not burnout between twelve to sixteen month group relampings. The total average on-time for yellow signal lamps used in this study is 681 hours in sixteen months.
  
- o There are other causes of lamp failures than total average on-hours. These are: traffic and wind induced shock and vibration, the pole and signal head mounting that amplifies and transmits the shock and vibration to the lamp, and temperature extremes. Lamps with installed lifetimes of between 5,000 to 8,000 hours will allow for determining the magnitude of these other lamp failure causes.

## RECOMMENDATIONS

- . Issue a traffic signal lamp specification requiring quality control checks, inspections and referencing ownership costs initially from the results of this project and then from the more than 60,000 lamps that would be installed from a statewide group relamping. A traffic signal lamp specification alone is inadequate to improve traffic signal lamp lifetimes.
- . Group relamp traffic signal lamps and monitor all traffic signal lamps for reasons of removal. Prepare a timing data base from timing sheets and use this to calculate total average on-hours using the installation and removal dates for each burned out lamp. Develop ownership cost tables to use in the next traffic signal lamp bid.
- . Obtain cooperation from other states, municipalities and political subdivisions in using the above recommended approach since some traffic signal lamp manufacturers get more orders by accident than by deliberate marketing. The traffic signal lamps are a very small part of their overall business. With the recommended approach more than one of the traffic signal lamp manufacturers might not bid on New Jersey's specification unless other users also adopted the same or similar approaches.
- . Software and/or hardware resettable accumulated total on-time and total cycle time indicators for each traffic signal lamp for each signal face at an intersection

would aid in implementing the results of this project. Only the data on lamps that burned out before group relamping would be required for ownership cost determination. The ideal total on-time and cycle time indicators are those that would be built into the hardware and software of the controllers.

## IMPLEMENTATION PLAN

The detailed plan for implementing the results of this project are contained in Appendix 12. The outline of the plan is:

- . Contact other states and political subdivisions to obtain information on their relamping and specification.
- . Develop a questionnaire to send to the traffic signal lamp manufacturers concerning their manufacturing process. Use this information to write a traffic signal lamp specification.
- . Using the techniques from the project, develop procedures for a traffic signal lamp timing, installation, removal and burnout data base to be used to develop ownership cost tables for the installed lamp type for use on the next traffic signal lamp bid.

Implementation of the results was started.

Twenty-two states were contacted for their experience, practices and procedures followed with traffic signal lamps.

A questionnaire was developed and sent to six traffic signal lamp manufacturers for information to be used in writing a detailed specification. Some replies were received.

A new set of forms were printed for use by electrical mechanics for group relamping and monitoring of burnouts.

The results of the project were presented to the Director of Construction and Maintenance Engineering and his staff. At that time four recommendations were made. These are:

- . purchase Krypton Watt-Saver 135 watt lamps for twelve-inch signal faces requiring that the krypton fill gas be at least 80%.
- . purchase standard lamps for eight-inch signal faces.
- . write a specification for traffic signal lamps and use the project derived ownership cost tables for each lamp type to determine the bid winner.
- . group relamp with lamp records being maintained through lot numbers, installation sheets and burnout/removal sheets in order to update the lamp type ownership cost tables for the next bid.

## INTRODUCTION

There has been a long standing desire by the Department of Transportation to increase the installed lifetimes of traffic signal lamps.

The Manager of the Electrical Bureau requested that research efforts be devoted to increasing the lifetime of installed traffic signal lamps because of the number of lamps that were burning out before the annual group relamping.

In response to this request a proposal was written after an intensive investigation, literature search and visits to the production lines of three lamp manufacturers. The plan was to have traffic signal lamp manufacturers assemble test lamps on their production lines. The materials, components, gases and finished lamps would be subjected to various quality control checks and inspection before, during, and after assembly.

Test lamps would be installed in the field and the lifetime of the lamps monitored. Failure modes of the lamps would indicate which quality checks and inspection points should be retained and what new ones added.

Included in the proposal was the goal of reducing traffic and wind induced shock and vibration in traffic signal heads thereby increasing lamp lifetimes. Field measurements of traffic and wind induced shock and vibration would be made for each of the various poles, mast arm and signal head configurations. The same pole, mast arm and signal head configurations would than be shocked and vibrated on an aerospace vendor's shake table simulating field shock and

vibration conditions. Various techniques and methods would be evaluated for the reduction of shock and vibration to acceptable levels.

The request for research and the proposal responding to this request was issued over two decades ago.

The Energy Coordinator in the New Jersey Department of the Treasury inserted a formula into the traffic signal lamp bid specification that was based upon lamp efficiency and the mean lifetime of the traffic signal lamp as stated by the lamp manufacturer. Chatham Engineering won the 1981 traffic signal bid for eight-inch lamps with a manufacturer rated lifetime of 16,500 hours for their krypton thermistor lamps. The lamp price was \$3.63 each.

Sylvania and Westinghouse lamps for eight-inch signal faces that were installed in traffic signal heads at that time had a rated life of 8,000 hours and costs \$0.31 each.

The Manager of the Electrical Bureau requested that various types of traffic signal lamps be evaluated through field installations since documentation on the field lifetimes of krypton thermistor lamps was not available, their costs to purchase was over ten times the lamps that were in use, and the previous proposal for increasing lamp lifetimes provided a knowledge base for writing another but less ambitious proposal.

## BACKGROUND

The National Cooperative Highway Research Program Synthesis titled, "Maintenance Management of Traffic Signal Equipment and Systems" concludes that the frequency of failure and the length of time that the signal is "down" are strongly related to the quality and level of maintenance that is provided. Proper maintenance also determines to some extent equipment life.

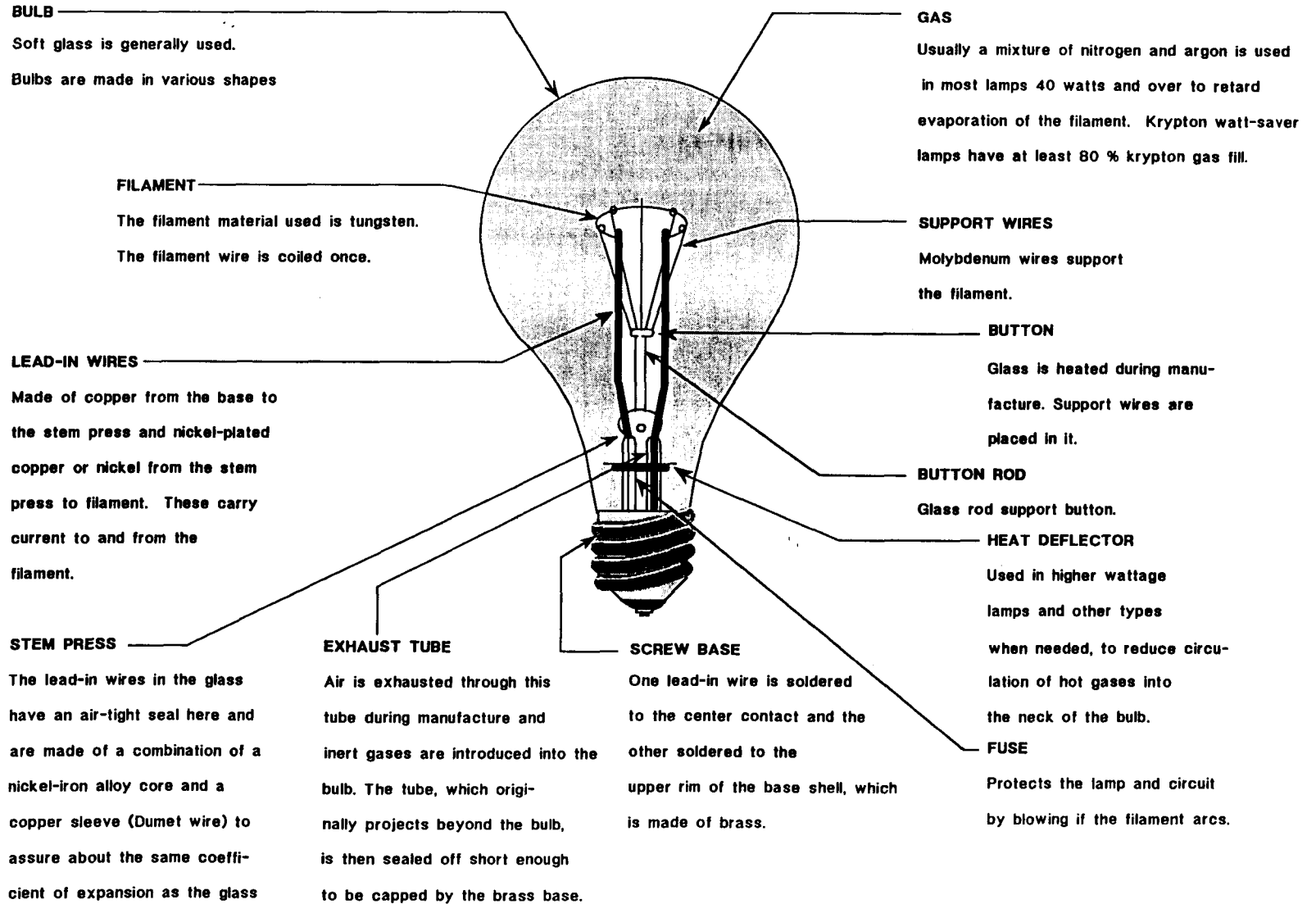
A typical traffic signal lamp and components are shown in the figure on the following page.

One component of a signal system that proper maintenance cannot deter from unpredictable failure is the traffic signal lamp.

A standard traffic signal lamp for either an eight-inch or twelve-inch signal face is specified at a mean life time of either 6,000 or 8,000 user hours. This 8,000 hours is an average life time of all of the lamps. Fifty percent of the lamps can burnout before 8,000 hours. Typically traffic signal lamps burnout anytime from the initial turn on to the time that surviving lamps are replaced at an intersection. The unpredictable maintenance force demand causes both safety problems at the intersection where the lamp or lamps have burned out and replacement costs considerably greater than the cost of any lamp available.

Traffic signal lamps that are found to be defective in either material or workmanship during the initial installation phase are exchanged on a one for one basis with the lamp vendor. A defective lamp which burns out within 200 hours of installation and is deemed a "leaker" (oxygen is drawn into the

# Traffic Signal Lamp



particle vacuum surrounding the filament by a defective seal) can be exchanged.

A defective lamp or burned out lamp causes that particular color signal to be "down" from the time of the burnout to replacement. If replacement is deemed necessary at a time other than normal working hours a police backup is normally required. A minimum of two hours of premium time is required for the maintenance crew (perhaps more) to install the lamp. If replacement takes place during normal working hours then the previously scheduled electrical maintenance must be delayed. The actual lamp replacement does not take more than a couple of minutes. What takes time is the necessary safety set up and tear down. Even on a complete intersection relamping, only approximately ten intersections per day can be relamped because of the safety considerations.

There are many different types of lamps produced today by manufacturers and they are believed to vary widely in actual field lifetimes. The lamp lifetime is determined by the manufacturer by choosing a sample of lamps and burning them at a higher than rated voltage, accelerating their burnout. The lamp life is determined through a formula such as

$$L = L_0 \left( \frac{V_0}{V} \right)^n$$

Where  $L_0$  = life at rated voltage

$L$  = life at operating voltage

$V_0$  = rated voltage

$V$  = average operating voltage

$n$  = 14 for gas filled lamps.

The lamps that are tested to determine lamp life have not been subjected to storage in the manufacturers' plant before purchase, shipment, storage in the central warehouse, shipment to the regions, storage in the regions, the shock and vibration from being transported in the maintenance vehicle, and the actual operation with its cycling and on-time variability (filament evaporation and migration), wind and traffic induced shock and vibration, and temperature extremes. The life rating for the lamp is determined in an environment different from the environment in which the lamp is used.

#### Lamp Life

A lamp's life can be determined mainly by the quality of the vacuum and the purity of the gases surrounding the filament. If the seal and gases are as specified then the next most important factors are: 1) the quality of the filament manufacture, 2) cycle time and on-time, 3) environment - traffic and wind induced shock and vibration, temperature extremes, 4) rated voltage versus actual voltage, and 5) the combined effects of the previous.

Filament Manufacture - The quality of the manufacture of the filament from the raw tungsten to the finished filament in the lamp determines lamp life. Contamination of the filament with impurities or slight nicks (.0001") or non-uniform coiling of the filament (causing hot spots) shortens lamp life. The filament is coiled once from a

tungsten wire that is thirty-six inches long to a length of less than three inches.

Because of the long filament, filament support wires are added to prevent filament sag when the filament is energized.

Cycle Time and On-Time - Background cycle time determines the number of times that a lamp is turned on. In the first hundreds of a second after the lamp is energized and before incandescence, current passing through the filament is between 8 to 15 times the normal or steady state current. These transients contribute to the shortening of lamp life. To illustrate the variability of the number of transients to which various lamps would be subjected, simple intersections are considered. The comparisons are contained in the following Table.

In actual use most of the signals are semiautomatic in operation i.e., within limits the signal responds to the traffic volume. During late night and early morning hours the signal is green on the main street and red for the smaller cross streets unless a vehicle is detected on a side street. Correspondingly, a rule-of-thumb is that the green on the main street and the red on the side street will burnout earlier than other lamps installed in the intersection at the same time because of the longer on-time.

TABLE I

Phase times per color in seconds			Total number of turn ons per year			Total on time per year in hours		
Red	Yellow	Green	Red	Yellow	Green	Red	Yellow	Green
25	5	30	525,600	525,600	525,600	3,650	730	4,380
40	5	45	350,400	350,400	350,400	3,893	487	4,380
25	5	20	350,400	2,452,800	350,400	2,433	3,407	2,920
for 16 hours/day with 8 hours/day yellow flash - 5 sec.								
25	5	30	2,452,800	350,400	350,400	5,353	487	2,920
for 16 hours/day with 8 hours/day red flash - 5 sec.								
Side street 25	5	30	350,765 (minimum)	350,400	350,400	5,353 (maximum)	487	2,920
for 16 hours/day Red on continuously for 8 hours a day unless a vehicle is detected.								
Main thorofare 25	5	30	350,400	350,400	350,765 (minimum)	2,433	487	5,840 (maximum)
for 16 hours/day Green on continuously for 8 hours a day unless a vehicle is detected on the side street.								
Flasher Installation either red or yellow 1			31,536,000	31,536,000	---	4,380	4,380	---
						(assumed 1/2 of time equivalent on time)		

Environment - In addition to the daily and seasonal temperature extremes shock and vibration have long been recognized as being detrimental to the life of traffic signal lamps particularly when shock or vibration is applied to the lamp when it is on. Experiments have confirmed that low frequency vibrations put the filaments of traffic signal lamps into resonance. One means of reducing the effects of the shock and vibration is to add filament support wires. Traffic signal lamps in this test have three, five and six filament supports which prevent filament sag under-shock when the lamp is on and reduces excursions of the filament under repeated vibrations. The number of supports is a compromise between providing adequate support for the filament and reducing the light output because of the supports. Since the support wires are not heated except from the filament, a small region around each support is at a lower temperature than the rest of the filament. Hence, as the number of supports increases for the same filament type, the light output decreases.

Under sever shock, as might exist at intersection locations with pot holes or broken pavement, the hot filament is stretched or sags at the support point causing unequal spacing of the coils in the coiled filament. Migration of the tungsten from the hotter close coils of the filament to the cooler coils near the supports takes place. Failure can be caused by either additional shocks causing additional hot filament sags, tungsten migration and or filament evaporation.

Wind induced shock and vibration has the same effect on traffic signal lamps as that induced by traffic. Electrical mechanics expect to receive calls to replace burned out traffic signal lamps after a thunderstorm accompanied by high winds, or after a winter storm accompanied by high winds. Lamps that normally would last for many hundreds of hours longer burnout earlier because of the wind caused shock and vibration.

Rated Voltage Versus Actual Voltage - Operating a lamp outside the rated voltage can alter lamp life. Generally, every 1 percent change in applied voltage modifies lamp wattage by 1.5%, efficiency (lumen/watt) by 2% and light output (lumens) by 3.5%. For a 5% increase in operating voltage over rated voltage, lamp life is reduced by 50%.

The electrical needs of the State of New Jersey are furnished by five small local companies and four major suppliers (New Jersey Central Power and Light, Public Service Electrical and Gas, Atlantic Electric and Rockland Electric). The test area in southern New Jersey is supplied by two major companies, Public Service Electric and Gas and Atlantic Electric. For these two companies the supply voltage in a signal head is not expected to exceed rated voltage for that head. However, a higher rated voltage lamp installed in a lower voltage signal head can increase lamp life. Generally the other factors affecting lamp life prevent the increased lamp lifetime from being realized by using a higher rated voltage lamp at a lower voltage. The net effect is light output lower than specified.

## Lamp Types

Ownership costs can be considerably affected by lamp types. Different types of lamps have been developed for which the manufacturers have made various claims concerning energy efficiency, and extended life when compared to the standard tungsten lamps. These lamps are krypton, energy efficient or "watt-saver," and krypton thermistor.

Standard Lamp - Argon nitrogen gas is used to fill the partial vacuum surrounding the filament of a standard lamp to prevent filament evaporation and arcing.

The standard lamp is not efficient at visible light production. Of all of the energy given off by a tungsten filament, operating at between 2800°K to 3000°K color temperature, only between 8 to 10.4% of the energy can be detected by the human eye. The rest of the energy is given off at infrared wavelengths and less than 1% in the ultraviolet portion of the spectrum. Some of the visible infrared energy is absorbed by the glass causing it to be "hot" to the touch. The rest is transmitted to the air and surrounding surfaces. The internal heat generation combined with daily and seasonal temperature extremes causes stress on the bulb, seals and lamp components that can shorten lamp life.

Krypton - Krypton (6 times the atomic weight of argon nitrogen) has been substituted for some of the argon nitrogen at a rate of 80% minimum of the gas in the lamp. The heavier krypton atoms surrounding the filament is thought to reduce the evaporation of tungsten from the filament thus resulting in lamps with longer lifetimes. Tungsten migration from hotter areas of the filament to cooler areas is not affected.

Energy Efficient or Watt-Saver - With krypton in a lamp reducing evaporation of the filament, the filament can be designed to operate at a higher temperature increasing the light output without reducing the lamp life. The power requirements are reduced - hence the term "watt-saver" or an energy efficient lamp. Normally, a 67 watt lamp can be replaced by a 60 watt "watt-saver" lamp for an eight inch traffic signal face, without any loss in lumen output throughout the life of the lamp. Using the 60 watt "watt-saver" in an eight inch signal face would result in 11.7% energy savings. A 150 watt lamp can be replaced by a 135 watt "watt-saver" lamp for an energy savings of 11.1% for the twelve inch traffic signal.

The objective of this project is to determine the lamp type with the lowest ownership cost where only purchase price and maintenance cost are considered. Should an energy efficient lamp satisfy these requirements then this is an added benefit of the lamp type but not an objective of the project.

Krypton Thermistor - Thermistor material is made by sintering mixtures of metallic oxides, such as magnesium, nickel, cobalt, copper, iron and uranium. Thermistor materials unlike metals have a negative temperature coefficient of resistance, i.e., as the temperature (either internal or external) increases the resistance decreases. The resistance of a typical tungsten filament is very low when it is cold. When voltage is initially applied to the lamp turning it on, the current transients through the filament can be 8 to 15 times steady state values. With the addition of a thermistor washer in the fixture (lamp socket) or incorporated into the lamp, the transients are reduced to the steady state value or less. This is accomplished by the current passing through the thermistor washer, heating up the washer because of the high resistance. Heating of the material causes the resistance to decrease as the temperature increases. Increasing current passing through the filament causes the resistance of the filament to increase until operating temperature is reached. The resistance of the thermistor material decreases as the filament resistance increases with increasing current toward the steady state value. The net effect is that the transients are reduced to steady state values or less. The voltage drop across the thermistor reduces the voltage across the filament causing the filament to operate at a slightly lower temperature (and less light output). This operation at a lower temperature also reduces the evaporation and migration rate of the tungsten.

Krypton thermistor lamps have a manufacturer rated life time of 16,500 hours.

## LITERATURE SEARCH

A Highway Research Information Service Search was received titled "Traffic Signal Lamps." Only two references were listed. These two "Conservation of Electrical Energy as Related to Traffic Technology," International Municipal Signal Association (IMSA) Signal Magazine, 3 pages, September - October 1973 and "Traffic Signal Lamp Performance," IMSA Signal Magazine, 2 pages, March - April 1970 were reviewed.

The former reference treats the reduction in energy consumption and corresponding dollar savings at signalized intersections provided the lamp intensity is controlled in response to ambient light conditions. The latter reference discusses the 1967 Institute of Traffic Engineers Traffic Signal Lamp Specifications and the ordering of the correct lamp.

This search (December 1981) and conversations with lamp manufacturers confirmed that there were no other projects that have been completed or were in progress similar in scope to this Project at that time.

Edward A. Mueller authored, "Aspects of the History of Traffic Signals" which is in the IEEE (Institute of Electrical and Electronic Engineers) Transactions on Vehicular Technology, pages 6-17, Volume VT-19, Number 1, February 1970. Traffic signal lamps are not considered in this paper.

## METHODOLOGY

### Lamp Selection

Traffic signal lamps for the first test were selected from six of the manufacturers of traffic signal lamps. Lamps for eight-inch and/or twelve-inch signal faces were received from Luxor, Duro-Test, Sylvania, General Electric, Westinghouse and Chatham Engineering.

Lamps were obtained from both contract and non-contract vendors. The manufacturers that were under contract were Chatham Engineering, Sylvania and Westinghouse. Lamps from these manufacturers were supplied at the current contract price.

The lamp manufacturers that were not under contract were Luxor, Duro-Test and General Electric. These manufacturers were contacted by the Energy Coordinator in the Department of the Treasury for complimentary lamps for inclusion in the test. These manufacturers were made aware of the intended use of their lamps.

The objective was to obtain at least one case (120 lamps) of each type of lamp from each recognized manufacturer of lamps for the eight and twelve-inch signal faces. One case of lamps was purchased from General Electric since these lamps were not otherwise available.

All three of the lamp types were included in the first test. These are standard lamps, krypton watt-saver lamps and krypton thermistor. All lamp types were not available from all manufacturers nor were they available for both eight and twelve-inches signal faces. Krypton Thermistor Gard lamps from

Chatham Engineering were only available for eight-inch signal faces. The other two lamp types are available in different wattages, voltages and filament support groups. Krypton watt-saver lamps were available only from Luxor and Duro-Test. Sylvania and Westinghouse lamps were obtained only for eight-inch signal faces.

Tables 1 to 7 in Appendix 1 completely identifies all of the lamp and quantities of lamps in Test 1 and Test 2.

Table 1 list the complimentary lamps.

Table 2 list the lamps that were purchased.

Tables 2, 3 and 4 identifies standard Westinghouse and Sylvania 67 watt, 130 volt, standard lamps as being "new" and "old." When the krypton thermistor lamp bid was determined to be the lowest bid according to a formula that included price, efficiency, and manufacturer rated lifetime, the Sylvania and Westinghouse lamps that had been under contract were continued under contract at the same price until verifiable field lifetimes of the krypton thermistor lamps could be established. These Sylvania and Westinghouse lamps that were purchased under the extended contract are identified as "new."

Sylvania and Westinghouse 67 watt, 130 volt, standard lamps were obtained from the Region IV maintenance yard. These lamps are designated "old" since they had been purchased six months before and had been in storage.

The new and old Sylvania lamps have six filament supports. The new and old Westinghouse lamps have five filament supports.

The two groups of lamps from different manufacturing lots separated by at least six months in time was included in Test 1 to determine the effect, if any, of storage on field lifetimes.

Table 5 in Appendix 1 further characterizes the Test 1 lamps into seven categories. This table is included to summarize the various characteristics of the lamps. Each column identifies all of the lamps according to the single characteristic.

Table 6 in Appendix 1 includes a column which lists the total quantity of lamps that were installed for each quantity of 120 lamps received. Not all of the lamps received were installed. Lamps were not installed for various reasons that became apparent during the installation of the lamps.

Table 7 in Appendix 1 identifies the lamps that were selected for Test 2. Test 2 started after the results of the first three year test were known. Test 2 lasted one year to confirm the results of Test 1.

For Test 1, 1440 lamps for eight inch signal faces and 600 lamps for twelve-inch signal faces were received. For Test 2, only 480 standard lamps for eight-inch signal faces were received. However, 951 lamps were received for twelve-inch signal faces.

#### Lamp Identification

Individual lamps were identified by using an electric engraving pencil to mark a two letter code and sequential number on the brass base of the lamp. The first letter represented the lamp manufacturer and the second the lamp types as defined on the bottom of Table 4 in Appendix 1.

Table 3 and Table 4 in Appendix 1 characterizes the Test 1 lamps by lens (signal face) size - eight or twelve-inch, number of filament supports - 3, 5, or 6 and the identification letters and numbers used for lamp traceability.

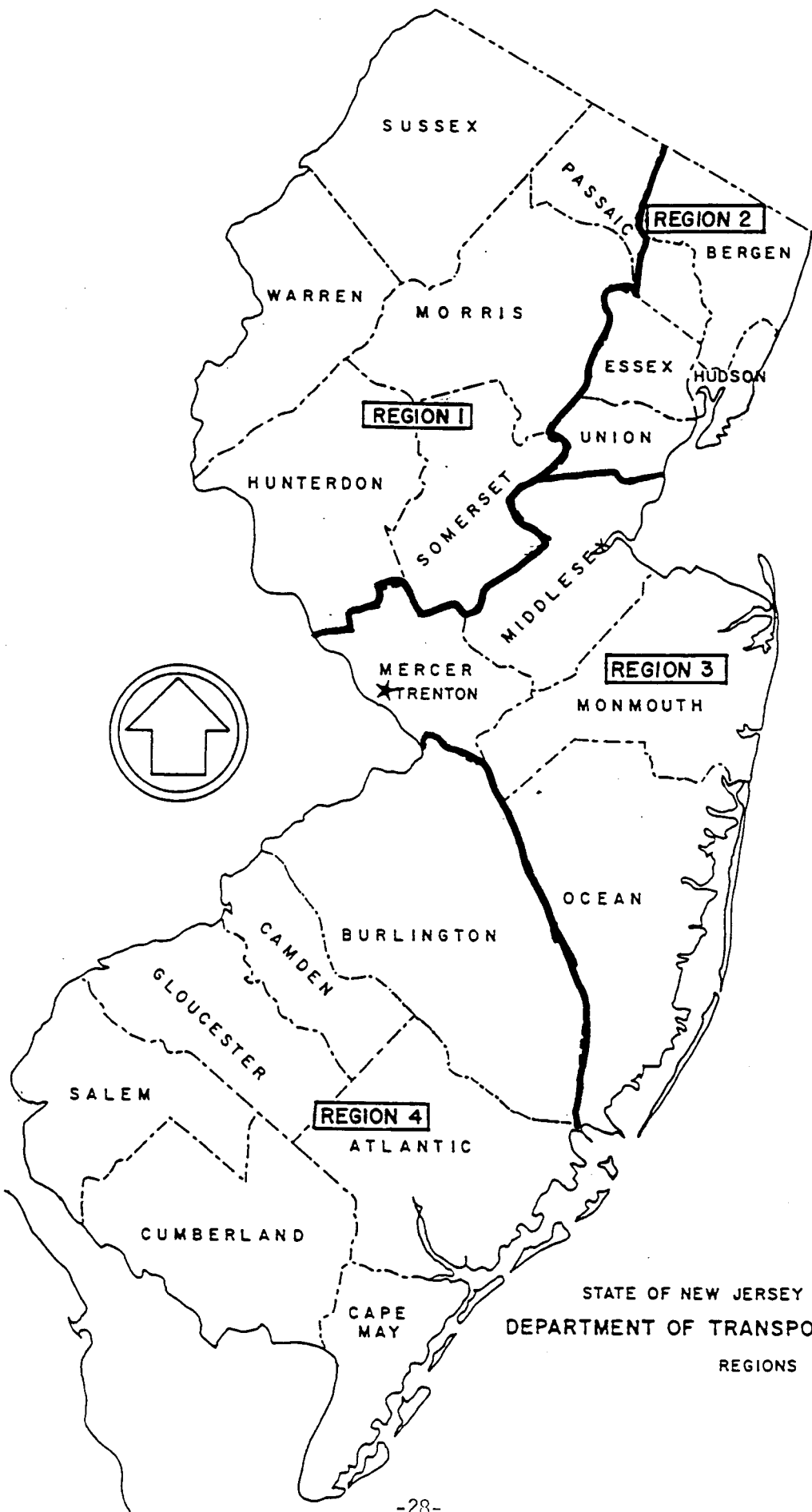
The lamps used in Test 2 were identified only with a sequential number on the brass base. These identification numbers for each manufacturer's lamp are listed in Table 7, Appendix 1.

#### Test 1 and Test 2 Installation Sites

Design, Construction, and Maintenance Region IV, consisting of seven southern New Jersey counties was, selected for Test 1 and Test 2. The Region (as shown in the figure on the following page) is the largest in the State and provided the largest variety of signalized intersections along with the consistent manpower and equipment required for the project. Another criteria that this region satisfied was that there be group relamping on a twelve to sixteen month basis so that all of the test lamps could be installed in a short period of time. Some of the other Regions replace lamps as they burnout because manpower is not always available for group relamping.

#### Test Site Selection

Appendix 2 contains tables which identifies each intersection where lamps were installed for Test 1 (pages 2-2 to 2-7) and Test 2 (pages 2-8 to 2-11). The tables lists the control section number which is also on the traffic signal controller cabinet at the intersection, the intersecting



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street, the main route, the municipality, the county, the numbers of eight-inch lamps and twelve-inch lamps used, the traffic signal controller manufacturer, the controller model number and the controller type.

The Electrical Bureau supplied a proposed list of intersections to be used in the test. Plans for each intersection were reviewed for the layout and for the number of eight and twelve-inch lamps that could be installed. Visits to each intersection were made and each intersection was evaluated for inclusion in the test. Intersections were rejected because of broken pavement, planned reconstruction within a year and for signal revisions that were possible or being considered in the next sixteen months at the intersection.

The table for Test 1 lists seventy-six signal intersections of which fifty-eight are traffic and eighteen are flasher.

The intersections used in Test 2 includes some intersections that were used in Test 1 and additional intersections that were added to accommodate more lamps for twelve-inch faces than were used in Test 1. Fifty-three intersections were used in Test 2. Twenty-seven of these were also used in Test 1.

In Appendix 2 (page 2-12) the traffic signal controllers used in both tests are summarized by manufacturer, model number, type and quantity in this table. The Department of Transportation uses a generic specification for controllers for bidding and accepts the lowest bid controller. This is the reason for the variety of controllers that are used.

## Installation of Lamps

Lamps from each manufacturer were randomly placed in each intersection.

The lamps from each of the manufacturers were repackaged into other boxes for installation to insure that lamps were placed randomly in an intersection. Groups of three lamps taped together from the same manufacturer, all with the same characteristics, were sequentially taken from each manufacturer's shipping box and placed in another field installation box for eight and twelve-inch faces. This repackaging of the lamps insured that a variety of lamps from each of the manufacturers were placed in an intersection and prior selection of lamps for installation in particular signal heads was not required.

Lamps for flasher installations were placed in bags along with the installation sheets for that intersection.

The installation sheets were prepared for each intersection from intersection drawings.

An installation sheet contains a sketch of the intersection with signal head numbers indicated, an arrow on each head indicating the direction the head faces, the route number, the intersecting street name, a set of three boxes under each signal head number (separate from the roadway sketch) for recording the lamp number (one for each signal face color), the control section number, date, name of the person to contact for more information, etc. Eight and twelve-inch signal faces are designated. Signal faces that are crossed out are not to be used in the project.

Appendix 3 contains six installations sheets that were used in Test 1 and Test 2.

All of the lamp installation sheets and burnout sheets for the seventy-six intersections were delivered to Region IV electrical maintenance at the same time. A meeting was held with the supervisor and electrical mechanics where the project was completely explained and all questions answered.

The installation of the Test 1 lamps began on March 30, 1982.

A group of three lamps from the same manufacturer all with the same characteristics were placed in one signal head during installation - one in red, one in yellow, and one in the green signal face. As each lamp was installed at an intersection into a signal face the electrical mechanic recorded the lamp number in the box provided on the installation sheet corresponding to the signal head number and signal face color in which the lamp was installed. After installing the test lamps in the intersection, the carbon copy of the installation sheet was placed in the controller cabinet for reference when relamping and or for filling out burnout sheets. The original sheet was returned for data entry into the lamp data base.

The installation of lamps for Test 2 started on January 9, 1985. The installation procedures followed were the same as in Test 1.

#### Return of Lamps

When a test lamp was removed from a signal face a burnout sheet (Appendix 5) was filled out. Both the lamp and the burnout sheet was returned. The lamp was inspected to verify

the reason for removal. The information on the burnout sheet was checked. This includes the control section number, the street, the route number, the signal head number, signal face color, lamp base number, and cause of removal. Burnout sheet and installation sheet information was also compared for accuracy. Lamps were removed and returned because:

- . the lamp burned out
- . the signal was revised
- . the signal was vandalized
- . the signal face was accidentally relamped
- . the support pole was knocked down

#### End of Tests

The relamping of Test 1 lamps began on January 9, 1985. The Test 1 lamps that survived were removed and replaced with lamps that were under contract. If the intersection was included in Test 2 then the lamps that were removed were replaced with Test 2 lamps.

Test 1 was stopped at this time because the call outs to replace burned out lamps began to increase substantially due to most of the lamps exceeding their normal rated lifetimes in red and green signal faces.

Test 2 lamps were removed after one year of being installed.

The lamps that were returned at the end of each of the tests were checked along with the burnout sheets and then compared to the installation sheets to insure accuracy.

### Lamps Not Returned

At the end of the tests it was determined that some lamps were not returned. A total of 116 lamps in Test 1 and 45 lamps in Test 2 were not returned from the field.

Lamps that were not returned at the end of each test are listed in the Tables in Appendix 9. The individual lamps are identified by lamp number, control section number in which the lamp was installed, lamp manufacturer, lamp type, the signal head number, the signal face color and the installation date. Test 1 lamp data is on pages 9-3 to 9-5. Test 2 data is on page 9-6.

The largest number of lamps not returned from one intersection occurred at the end of Test 2. Twenty-seven Westinghouse, 130 volt, 67 watt, lamps for eight inch signal faces were not returned from a single intersection - 0313102. Westinghouse eight-inch lamps were the only eight-inch lamps under contract and therefore installed in Test 2.

The lamps that were not returned were excluded from the test and were not included in the data analysis (not included in the base number) since the only information available on these lamps was that obtained from the installation sheets.

## RESULTS AND DISCUSSION

### Timing Calculations and Assumptions

Calculations were made to determine the total average on-time and total average cycle time that each test lamp experienced from the day of installation to the day of removal.

It was assumed that, on the average, a traffic signal lamp is cycled on and off twenty-one hours a day. For the remaining three hours the green signal on the main road and the red signal on the side road was assumed to remain on unless activated by traffic on the side road during the early morning hours.

When an intersection uses a variable cycle timing or variable signal face timing the two cycle timings are averaged.

The on-time per background cycle (the time to complete one on off cycle for the intersection) for each signal face is determined from the installation timing sheets that are issued by the Bureau of Traffic Engineering. Five typical installation timing sheets are in Appendix 4. These sheets correspond to the installation sheets in Appendix 3.

To insure accuracy of the timing data, a signal head timing sheet was used to record timing data for each signal face in each signal head at an intersection. The average on-time per cycle in seconds and the total average cycles per day were calculated using data from the installation timing sheets and the results recorded on the signal head timing sheet. Data from this sheet was then entered into a data base named "timing."

Five signal head timing sheets for the intersections in Appendices 3 and 4 are in Appendix 6. A simple intersection with variable timing for red and green signal faces is included as an example in Appendix 6, pages 6-13 and 6-14.

Eighteen flasher intersections were included in Test 1. A lamp installed in a flasher cycles on and off every second. For this Test, the lamp is assumed to be on (filament temperature above a nominal value where filament evaporation takes place) for 0.5 seconds per one second on-off cycle or 43,200 seconds per day. Flasher installation timing is also found in Appendix 6 on page 6-15.

The first page of the timing data base file for each of the tests is included in Appendix 6 on pages 6-16 and 6-17.

#### Data Base and Programs

In the planning of the project, a data base structure was developed that contained a complete listing of the characteristics of the test lamps and characteristics of the intersections in which test lamps were to be installed. The data base in Appendix 7, with descriptions of each of the fields, is a smaller one than was initially considered. When planning the data base, the first test was estimated to last eighteen months maximum, lamps from a manufacturer were considered to have uniform installed lifetimes (this was especially true for the first test since the manufacturers of complimentary lamps were informed of the test purpose) and lamp types in a wattage category were thought to have similar lifetimes.

Since lamps did not burnout as anticipated, some of the fields in the master data base were not used in the analysis of the lamp data. These fields includes those that identify the poles, the road, the soil, and the lamp burning position, controller type, etc. The fields that were used were total average on-time, total average cycles, days installed and those fields that listed cause for removal.

The data analysis was started using a mainframe computer, moved to an IBM-PC AT when received and finally to an IBM PS-2 model 80 microcomputer. DBase III Plus and SAS, a statistical analysis software package, were used in the data analysis and to plot the graphs in the figures.

Descriptions of the microcomputer programs and examples of the programs are found in Appendix 7.

The timing program calculates the total average on-hours and total average cycles that test lamps experienced during the period of installation.

The flasher program calculates the total on-hours and total cycles for lamps installed in flasher signal faces.

SAS (Statistical Analysis Software) was the only program that was found that could take the large number of data points from the data base files and produce an accurate graph. The program that plots figure 2 in Appendix 11 is in Appendix 7 on pages 7-1 to 7-13.

## Chatham Engineering Lamps

Chatham Engineering krypton thermistor lamps installed at an intersection (not included in Test 1) caused problems with the lamp sockets. The maintenance forces replaced all of the krypton thermistor lamps with contract lamps and the lamp socket problems stopped.

All of the seventeen krypton thermistor lamps that had been returned from Test 1 at that time were inspected under 3X and 30X magnification. It was concluded that a production problem with solder voids under the wafer sized thermistor on the base of the lamp, the brittleness of the thermistor material, the misalignment of the thermistor wafer parallel at the base of the lamp and central pressure from the traffic signal lamp socket all contributed to the cracking of the thermistor wafer. Thermistor wafer pieces became detached and shorted out the lamp sockets in the intersection not included in Test 1.

Details of the 3X and 30X magnification of the seventeen krypton thermistor lamps are in Appendix 10.

### English Electric Test Lamps

English Electric supplied three test lamps for evaluation. The lamps were General Electric tungsten halogen projector lamps that were installed in a brass screw in fixture designed so that the light center length was the same as for a normal traffic signal lamp. The lamps were designed to operate on twelve volt fifty five watt direct current.

There was an initial concern that if these lamps were used in the field they could be screwed into a fixture that had 120 volt alternating current with the potential for injury to the electrical mechanic installing the lamp. The lamp was inserted into a 120 volt socket and the switch turn on. The current travelled across the quartz base pinching the filament off where the two power leads entered the quartz bulb. The quartz bulb was not damaged. The electrical insulation of the quartz envelope is inadequate to prevent 120 volt A.C. from shorting out the power leads at the base of the filament.

The second lamp was installed in a traffic signal head in the laboratory where the power had been stepped down to operate at less than fifty-five watts and twelve volts. The brightness was judged to be equal or greater than a standard lamp operating in the same fixture at normal power. The lamp was installed on March 22, 1983 and burned out in April 23, 1986 after burning continuously for three years and thirty-one days or 27,024 hours. The third lamp was similarly tested and burned for over 26,000 hours.

These lamps were not subjected to the normal environmental conditions that traffic signal lamps experience at an intersection. Field evaluation is required before recommendations can be made for their use.

### Tables

Detailed results of Test 1 and Test 2 are in tabular form in Appendix 8. In Table 1 corresponding to Test 1 are listed each quantity of 120 lamps according to signal face size, manufacturer, volts, watts, lamp type, quantity installed, quantity not installed, lamps not returned at the end of the test, lamps knocked down, lamps accidentally relamped, lamps vandalized, lamps installed in flasher signal faces, flasher burnout, no flasher burnout, traffic burnout, no traffic burnout and the base number used.

Table 2 contains the results of Test 2. The column headings are the same as for the Table for Test 1 except accidental relamping and flasher columns are not included.

The base number is the number that is used to calculate the accumulated percent burnouts and is the number of lamps installed less the lamps not returned. Lamps not returned are in Appendix 9.

### Best and Worst Case Assumptions

The figures that are in Appendix 11 contain best and worst case in the title of the figure. In determining the accumulated percent burnouts only lamps that were installed, burned out and were returned at the end of each test were included in the

calculations. This is the best case. Best case does not include lamps not installed, lamps not returned, lamps knocked down, lamps replaced because of accidental relamping or vandalized lamps.

Worst case assumes that lamps knocked down, lamps removed because of accidental relamping and vandalized lamps burned out on the date of their removal. Only two figures in Appendix 11 contains worst case assumptions. These are figures 25 and 26.

### Figures

All of the data that is plotted is contained in the figures in Appendix 11.

The program that plots Figure 2 in Appendix 11 is in Appendix 7 pages 7-11 to 7-13. This program is similar to all of the programs written to plot the figures in Appendix 11.

The Traffic Signal Lamp Chart on page 11-5 summarizes the plotted data in the figures contained in Appendix 11. The Chart identifies the figure by figure number, by best case or worst case, by lamp type or by manufacturer, by the variables days, hours or cycles, by the installation type - traffic and flasher or traffic or flashers and by the lamps - for either eight-inch and twelve-inch or either eight-inch or twelve-inch signal faces.

The ordinates for all of the graphs in the figures except the ones in figures 29 and 30, are labeled, "Accumulated Percent Burnouts." The abscissa for all of the graphs, excepts the ones in figures 29 and 30, are labeled, "Days Installed," "Total Average On-Hours Installed," or "Total Average Cycles."

The figures with "Accumulated Percent Burnouts" plotted against "Days Installed" (Figures 1, 5, 7, 10, 13, 16, 19 and 22) do not adequately compare lamp lifetimes since a lamp behind a yellow lens will be on for less than 512 hours in a year while a lamp behind a green lens on a main road will be on for 5,000 hours or more. If both lamps burned out on the same day and were plotted they would be included in the same point in the figure if they were from the same manufacturer, same lamp type, same wattage, and same voltage group. Yet the on-time and cycle time would be significantly different.

The figures with "Accumulated Percent Burnouts" plotted against "Total Average Cycles" (Figures 3, 4, 9, 12, 15, 18, 21, and 24) do not adequately compare lifetimes of lamps installed in traffic signal or flasher faces since for a properly manufactured lamp the on-time - filament evaporation-time - determines lamp lifetime provided other lamp lifetime influences are minimal.

Figures 1, 3, 4, 5, 7, 9, 10, 12, 13, 15, 16, 17, 18, 19, 21, 22, and 24 are included to show the data. These graphs "Accumulated Percent Burnouts" verses "Days Installed" or "Total Average Cycles" do not accurately predict lamp lifetime by comparison with the "Total Average On-Time Installed" figures. However, the conclusions that can be drawn from those figures would be the same as those drawn from Figure 2. These figures do not contradict the conclusions drawn from Figure 2.

In Figure 2 the "Accumulated Percent Burnouts" for the "Total Average On-Hours Installed" for the best case by lamp type shows the results of this project.

- . krypton watt-saver twelve-inch lamps have the lowest accumulated percent burnouts (APB) of all of the lamp types.
- . the standard lamps for eight-inch signal faces have the next lowest APB. However the APB for these lamps are much higher than for the krypton watt-saver twelve-inch lamps.
- . the standard lamps for twelve-inch signal faces have the next lowest APB. The APB of the twelve-inch standard lamps are not that much different than the APB of the eight inch standard lamps after 5,000 total average on-hours installed.
- . krypton thermistor eight-inch lamps and krypton watt-saver eight-inch lamps have similar APB and have the highest APB after 3000 hours.

In Figure 6 the APB versus on-hours for flashers is shown. The conclusions drawn from Figure 2 are still valid except that the krypton watt-saver eight-inch lamps have the highest APB. The data is limited. Figures 4, 5, and 6 have identical curves. The only difference is the abscissa scale multiplier to obtain days installed, to obtain cycles, to obtain total average on-hours since a flasher cycles on and off every second.

In Figure 8 for twelve-inch lamps, Duro-Test krypton watt-saver lamps have the lowest APB with Luxor krypton watt-saver lamps having the next lowest APB below 9,000 total average on-hours installed. Burnouts during installation kept the General Electric 165 watt standard lamps from having the lowest APB. The APB of twelve-inch lamps installed in flasher

installations is shown in Figure 11. Only 26 twelve inch lamps were installed in flashers and only 9 burned out.

Luxor and Duro-Test eight-inch standard lamps have the highest APB as shown in Figure 14. The lamps with the lowest APB are General Electric, Sylvania and Westinghouse lamps.

The data for eight-inch standard lamps that were installed in flasher installations and burned out is plotted in Figure 17. Again (like the lamps installed in traffic signals Figure 14) Duro-Test and Luxor standard lamps for eight-inch signal faces have the highest APB. General Electric standard eight-inch lamps have the next highest APB. Only one Westinghouse eight-inch lamp ("New" lamp since "Old" ones were not installed in flashers because of the application) burned out after 10,000 hours. Eleven Westinghouse eight inch standard lamps were installed.

The terms "New" refers to the standard eight-inch Westinghouse and Sylvania lamps that were purchased under the extended lamp contract. The term "Old" refers to lamps from the same manufacturers that had been in storage in the maintenance yard warehouse and had been purchased at least six months before.

Figure 20 shows that the "New" Sylvania lamps have lower APB than the "Old" Sylvania lamps. The Westinghouse "Old" lamps have lower APB than the "New" Westinghouse lamps. This flip-flop in APB between "New" and "Old" lamps from the two manufacturers is attributed to production line quality control and the variability of the quality due to the lack of automatic controls.

When a single production line can produce more than 3,000 lamps per hour (50 per minute) automatic controls of the production lines is necessary to detect insufficient vacuum, improper gas fill, improper gas mixture, oxygen in a completed lamp, and filament inspection under at least 600 magnification if not higher. Among the prior explanations for receiving a bad lot of lamps was that they were stored too long before use.

The above statements are derived from visits to lamp manufacturer production lines prior to the start of this project and discussions with the electrical mechanics. To summarize these discussions with the electrical mechanics no matter how good a lamp manufacturer is one can always get a defective lot. The reader is therefore cautioned to consider that all manufacturers of a particular lamp type have the same type of quality in their lamps at one time or another if the production line does not have automatic controls for detection of defects in each lamp and the automatic rejection of a defective lamp.

Figure 23 shows the data for the three General Electric lamps that have voltage ratings of 120 or 130 volts, wattage ratings of 67 or 69 watts and have either three or five filament supports. The Sylvania lamps are rated at 130 volts, 67 watts and have six filament supports. The variability of APB for the lamps with the various filament supports is again attributed to the manufacturing production line quality control. The theoretical order of lowest APB to highest based on the traffic and wind induced shock and vibration environment (the lamps with the most supports should last longer) should be Sylvania 130-67-6 (volts-watts-filament supports) then General Electric

130-67-5, then General Electric 120-69-3 and finally General Electric 120-67-3. Instead it is General Electric 120-69-3, then Sylvania 130-67-6, then General Electric 130-67-5 and finally General Electric 120-67-3.

Returns of burned out lamps from the field showed evidence that the filament had been stretched near the filament supports and in some instances the filament burned out at one of these points. It is suspected that in a traffic and wind induced shock and vibration environment the filament and supports vibrate at different frequencies causing the filament support to act like a tool opening the coils of the filament.

Figures 25 and 26 contain the worst case APB for krypton watt-saver twelve inch lamps. In Figure 25 the best case for the other lamp types are plotted. In Figure 26 the worst case for all other lamp types are included. (Worst case considers that lamps removed because of vandalism, lamps in signal heads that were knocked down and lamps removed because of accidental relamping burned out on the date of removal. Best case does not include these lamps.)

The conclusions drawn from Figure 2 are still valid in Figure 25 even though the worst case for krypton watt-saver twelve-inch lamps are compared to the best case for all of the other lamp types.

In Figure 26 the standard twelve-inch lamps have less APB than the standard eight-inch lamps. Otherwise the conclusions drawn from Figure 2 are still valid.

The data in Figure 2 is truncated and plotted in Figures 27 and 28 to better view the data below 9,000 total average on-hours installed. The abscissa in Figure 2 is scaled out to 25,000 total average on-hours installed. Figures 27 and 28 are plotted from the same data base except Figure 27 is plotted for 6,000 and Figure 28 is plotted for 8,000 total average on-hours. The region below 9,000 hours is expanded.

Tables 1 and 2 contain the ownership costs for the various lamp types. These costs are based upon the accumulated percent burnouts closest to 6,000 and 8,000 total average on-hours, the cost to replace burned out lamps at \$50 per callout per burnout and a variable lamp cost from \$.20 to \$5.00. The accumulated percent burnouts for each lamp type close to 6,000 total average on-hours for Table 1 and 8,000 total average on-hours for Table 2 was selected. The APB is listed at the top of each table in the column corresponding to the lamp type.

The cost per callout to replace a burned out lamp between the hours of 5:00 p.m. and 7:30 a.m. was estimated to be ninety-six dollars in 1986. This cost included the premium time for the electrical mechanics that was guaranteed by contract and the vehicle usage charges.

Costs were not included for the police backup that is required for all after working hours lamp replacement, nor was costs allowed for decreased safety at the intersection due to the burned out lamps.

All burned out lamps do not require premium time callouts. When a burned out lamp is replaced during normal working hours then the scheduled construction or maintenance has to be

delayed. Fifty dollars was estimated to be the average costs for twenty-hour callouts for lamp replacement. This number is below the \$250 per hour what one mid-western city was paying under contract for all types of electrical maintenance at an intersection irrespective of the type of maintenance required.

Tables 1 and 2 are plotted in Figures 29 and 30. The plots are parallel straight lines for each lamp type.

The plotted data and data in Table 2 shows that when one considers paying \$5.00 per lamp (an unrealistically high price) for a krypton watt-saver lamp for twelve-inch signal faces, the ownership cost per 1,000 lamps is \$7,100. The ownership costs per 1,000 lamps for standard lamps for twelve-inch faces when the cost is \$.20 each to purchase (an unrealistically low price) is \$9,100 - an increase in ownership of \$2,000 by using the standard lamp. This \$2,000 does not include a safety factor for a reduction in motorists safety at the intersection during the time that the signal face is not working.

There is also a potential for savings in the cost of power for the lamps. A standard lamp is rated at 165 or 150 watts. A krypton watt-saver lamp is rated at 135 watts. For 1,000 krypton watt-saver lamps in red or green signal faces on for at least 5,000 hours in one year the yearly savings in power costs can be \$6,000 when the cost per kilowatt watt-hour is \$.08.

When the lowest bid is accepted for traffic signal lamps, one considers that all other lamps that were bid are of equal quality. The only difference is a higher price. The results of this project shows that not all lamp types are equal in field lifetime and ownership costs. Initial lamp cost becomes

insignificant when one considers the costs to replace lamp burnouts before group relamping.

The present bid system without continual feedback from the field of lamp lifetime does not allow for the purchase of improved traffic signal lamps that cost more to purchase. Even purchasing krypton watt-saver lamps will not guarantee minimum ownership costs without field lifetime feedback.

Automation of traffic signal lamp production lines for the detection of defects will minimize the variability of lamp field lifetimes.

Probably the only way for automation of production lines for defect detection to take place will be for FHWA to sponsor a demonstration project. After consistent field lifetimes are obtained another demonstration project is needed to improve the design of the pole signal head system to minimize the transmission of traffic and wind induced shock and vibration to the lamp. The technology exists for both demonstration projects.

The data from Test 2 was not plotted. Only eighteen lamps for twelve inch signal faces out of nine hundred five burned out during the one year they were installed. Table 2 on page 8-5 contains the results summary.

There are a number of conclusions that can be drawn from this project.

Krypton watt-saver lamps for twelve-inch signal faces have the lowest ownership costs. This is based upon Figures 2, 29, 30 and Tables 1 and 2 in Appendix 11 and the above discussion.

Standard lamps for eight-inch signal faces have the next lowest ownership costs.

A traffic signal lamp specification requiring quality control checks, inspections, and referencing ownership costs from the last quantity of 60,000 lamps installed is a way of purchasing lamps with improved installed field lifetimes. This process will allow for lamps from manufacturers with improved but more expensive lamps to be purchased. The primary objective is the lamp with the lowest ownership costs, not necessarily with the lowest purchase price.

Manufacturers of traffic signal lamps can improve field lifetimes of their traffic signal lamps by increasing automatic control of their production lines to detect insufficient vacuum, improper gas fill, improper gas mixture, oxygen in a completed lamp, filament inspection under at least 600 magnification if not higher, and improving filament support wires so that in a shock and vibration environment the support wires do not become tools for opening the filament coil contributing to shortened lamp lifetimes. This is based upon visits to lamp manufacturers.

Consistent minimum traffic signal lamp lifetimes will allow for determining those intersections, pole head configurations, and head(s) to pole attachment methods that allow for traffic and wind induced shock and vibration to be transmitted to the lamp causing earlier than normal lamp failures. Lamp inspection of removed burned out lamps for filament coil stretching and/or the cause of the burnout would help determine those intersections with higher than normal wind and traffic induced vibrations.

Traffic signal lamps behind yellow signal faces should not burnout between the twelve to sixteen month group relampings. The total average on-time in sixteen months at six seconds on every 90 second background cycle is 681 hours for the test intersections. In the past in Region IV a number of intersections were group relamped when shortly thereafter the lamps started to burnout. Replacement lamp lots were not immediately available so lamps that had been removed from behind yellow signal faces were used in the interim.

Group relamping can be the most economical method of replacing traffic signal lamps provided predicted total average on-hours is used to determine the relamping schedule.

Comparison of lamp filament and fill gas analyses in parts per million or parts per billion of the lamps that survived more than 10,000 to 15,000 and 15,000 to 20,000 total average on-hours in the field with the lamp filament and fill gas analyses of lamps that burned out in the 2,000 to 5,000 total average on-hours range might yield information on lamp design and manufacturing quality control that could be used to improve installed lamps lifetimes. This analyses and the cost for same was not included in the original proposal.

The installed lifetime of a traffic signal lamp is determined by the total average on-hours provided traffic and wind induced shock and vibration are minimum and manufacturing defects are not present. The longer the total on-time, the greater the filament evaporation and migration of tungsten along the filament. Filament evaporation and migration is non-uniform across the filament and can occur in small areas of a single

coil. Once started this can accelerate reducing the cross sectional area of the filament until a turn on current transient causes the filament to break.

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APPENDIX 1

TRAFFIC SIGNAL LAMPS FOR TEST 1 AND 2

The Tables listed below contain data in tabular form for the traffic signal lamps used in Test 1 and Test 2.

TEST 1

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TABLE 1 - COMPLIMENTARY TEST 1 LAMPS SUPPLIED BY THE MANUFACTURER

<u>MANUFACTURER</u>	<u>VOLTAGE</u>	<u>WATTAGE</u>	<u>TYPE</u>	<u>QUANTITY</u>
Luxor	120	150	Standard	120
Luxor	120-125	135	Krypton Watt-Saver	120
Luxor	120-125	60	Krypton Watt-Saver	120
Luxor	120	67	Standard	120
Duro -Test	120	150	Standard	120
Duro -Test	120-125	135	Krypton Watt-Saver	120
Duro -Test	120-125	60	Krypton Watt-Saver	120
Duro -Test	120	67	Standard	120
General Electric	120	69	Standard	120
General Electric	120	67	Standard	120
General Electric	120	165	Standard	120
			TOTAL	<u>1,320</u>

TABLE 2 - PURCHASED TEST 1 LAMPS LISTED BY MANUFACTURER

<u>MANUFACTURER</u>	<u>VOLTAGE</u>	<u>WATTAGE</u>	<u>TYPE</u>	<u>QUANTITY</u>
Westinghouse (Obtained from maintenance yard - at least 6 months old)	130	67	Standard	120
Sylvania (Obtained from maintenance yard - at least 6 months old)	130	67	Standard	120
Westinghouse (New Purchase)	130	67	Standard	120
Sylvania (New Purchase)	130	67	Standard	120
General Electric	130	67	Standard	120
Chatham Engineering	120-130	69	Krypton Thermistor	120

TABLE 3 - TEST 1 LAMPS BY LEN'S SIZE, MANUFACTURER, AND VOLTAGE

LEN SIZES	MANUFACTURER	VOLTAGE	WATTAGE	TYPE	P-PURCHASE C-COMPLIMENTARY	NUMBER OF FILAMENT SUPPORTS	IDENTIFICATION LETTERS	NUMBERS	QUANTITY
12"	Luxor	120	150	Standard	C	5	LS	1-120	120
12"	Luxor	120-125	135	Krypton Watt-Saver	C	5	LW	1681-1800	120
12"	Duro-Test	120	150	Standard	C	5	DS	121-240	120
12"	Duro-Test	120-125	135	Krypton Watt-Saver	C	5	DW	1561-1680	120
12"	General Electric	120	165	Standard	C	3	EP	1201-1320	120
								SUBTOTAL	<u>600</u>
8"	Luxor	120-125	60	Krypton Watt-Saver	C	5	LW	1321-1440	120
8"	Luxor	120	67	Standard	C	5	LS	241-360	120
8"	Duro-Test	120-125	60	Krypton Watt-Saver	C	5	DW	1441-1560	120
8"	Duro-Test	120	67	Standard	C	5	DS	361-480	120
8"	General Electric	120	69	Standard	C	3	ES	1081-1200	120
8"	General Electric	130	67	Standard	C	5	ES	1921-2040	120
8"	Westinghouse	130	67	Standard-Old	P	5	WS	481-600	120
8"	Westinghouse	130	67	Standard-New	P	5	WS	961-1080	120
8"	Sylvania	130	67	Standard-Old	P	6	SS	601-720	120
8"	Sylvania	130	67	Standard-New	P	6	SS	841-960	120
8"	General Electric	120	67	Standard	P	3	ES	721-840	120
8"	Chatham Engr.	120-130	69	Krypton Thermistor Gard	P	5	CK	1801-1920	120
								SUBTOTAL	<u>1,440</u>

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TABLE 4 - ELECTRIC ENGRAVER INSCRIBED LAMP BASE CODE FOR TEST 1

	IDENTIFICATION		MANUFACTURER	VOLTAGE	WATTAGE	TYPE	C-COMPLIMENTARY		NO. OF FILAMENT SUPPORTS	LENS SIZE
	LETTERS	NUMBERS					P-PURCHASE			
1-5	LS	1-120	Luxör	120	150	Standard	C		5	12"
	DS	121-240	Duro-Test	120	150	Standard	C		5	12"
	LS	241-360	Luxor	120	67	Standard	C		5	8"
	DS	361-480	Duro-Test	120	67	Standard	C		5	8"
	WS	481-600	Westinghouse	130	67	Standard-Old	P		5	8"
	SS	601-720	Sylvania	130	67	Standard-Old	P		6	8"
	ES	721-840	General Elec.	120	67	Standard	P		3	8"
	SS	841-960	Sylvania	130	67	Standard-New	P		6	8"
	WS	961-1080	Westinghouse	130	67	Standard-New	P		5	8"
	ES	1081-1200	General Elec.	120	69	Standard	C		3	8"
	EP	1201-1320	General Elec.	120	165	Standard	C		3	12"
	LW	1321-1440	Luxor	120-125	60	Krypton Watt-Saver	C		5	8"
	DW	1441-1560	Duro-Test	120-125	60	Krypton Watt-Saver	C		5	8"
	DW	1561-1680	Duro-Test	120-125	135	Krypton Watt-Saver	C		5	12"
	LW	1681-1800	Luxor	120-125	135	Krypton Watt-Saver	C		5	12"
	CK	1801-1920	Chatham Engr.	120-130	69	Krypton Thermistor Gard	P		5	8"
	ES	1921-2040	General Elec.	130	67	Standard	C		5	8"

CODES: Duro Test-D Luxor-L  
 Westinghouse-W Sylvania-S  
 General Elec.-E Chatham Engr.-C

TYPES: Standard-S  
 Krypton Watt Saver-W  
 Krypton Thermistor-K

165 Watt - P - Equivalent to Standard

TABLE 5 - LAMP QUANTITY SUMMARY TABLE FOR TEST 1

6 MANUFACTURERS-QTY.	4 VOLTAGES-QTY.		6 WATTAGES-QTY.		LENS SIZES	3 LAMP TYPE-QTY.		PURCHASE & COMPLIMENTARY	TWO AGE GROUPS	NO. & QTY. FILAMENT SUPPORTS
Duro-Test	480	120	840	60	240	8"	Standard 1440	P - 720	One at least	3 - 360
Luxor	480	120-125	480	67	960		Krypton Watt-Saver 480	C - 1320	6 months older	5 - 1400
Westinghouse	240	120-130	120	69	240				than the other	6 - 240
Sylvania	240	130	600	135	240	12"	Krypton Thermistor 120		more recent	(The power
General Electric	480			150	240				purchases.	leads are
Chatham Engineering	120			165	120				Old - 240	not included
									New - 1800	in the fila- ment support count.)

TABLE 6 - TEST 1 LAMP DATA - NUMBER OF LAMPS INSTALLED

LAMP MANUFACTURER	LAMP IDENTIFICATION NUMBERS	VOLTS	WATTS	LAMP TYPE	FILAMENT SUPPORTS	LENS SIZE	TOTAL LAMPS RECEIVED	QUANTITY INSTALLED
LUXOR	LS-1 to 120	120	150	STANDARD	5	12"	120	115
LUXOR	LW-1681-1800	120-125	135	KRYPTON-WATT SAVER	5	12"	120	112
LUXOR	LW-1321-1440	120-125	60	KRYPTON-WATT SAVER	5	8"	120	118
LUXOR	LS-241-360	120	67	STANDARD	5	8"	120	120
DURO-TEST	DS-121-240	120	150	STANDARD	5	12"	120	114
DURO-TEST	DW-1441-1560	120-125	60	KRYPTON-WATT SAVER	5	8"	120	116
DURO-TEST	DW-1561-1680	120-125	135	KRYPTON-WATT SAVER	5	12"	120	116
DURO-TEST	DS-361-480	120	67	STANDARD	5	8"	120	119
GENERAL ELECTRIC	ES-1081-1200	120	69	STANDARD	3	8"	120	120
GENERAL ELECTRIC	ES-721-840	120	67	STANDARD	3	8"	120	120
GENERAL ELECTRIC	ES-1921-2040	130	67	STANDARD	5	8"	120	119
GENERAL ELECTRIC	EP-1201-1320	120	165	STANDARD	3	12"	120	115
SYLVANIA	SS-601-720	130	67	STANDARD	6	8"	120	120
SYLVANIA	SS-841-960	130	67	STANDARD	6	8"	120	120
CHATHAM ENGR.	CK-1801-1920	120-130	69	KRYPTON THERMISTOR	5	8"	120	120
WESTINGHOUSE	WS-481-600	130	67	STANDARD	5	8"	120	117
WESTINGHOUSE	WS-961-1080	130	67	STANDARD	5	8"	120	119
TOTALS							2040	2000

TABLE 7 - TEST 2 - LAMP DATA - NUMBER OF LAMPS INSTALLED

LAMP MANUFACTURER	LAMP IDENTIFICATION NUMBERS	VOLTS	WATTS	LAMP TYPE	FILAMENT SUPPORTS	LENS SIZE	TOTAL LAMPS RECEIVED	QUANTITY INSTALLED
Westinghouse	481 - 720	130	165	Standard	5	12"	240	237
Sylvania	721 - 960	130	165	Standard	6	12"	240	233
Luxor	1 - 240	120-125	135	Krypton Watt-Saver	5	12"	234	230
Duro-Test	241 - 480	120-125	135	Krypton Watt-Saver	5	12"	237	216
Westinghouse	961 -1440	130	67	Standard	5	8"	<u>480</u>	<u>470</u>
						TOTALS	1,431	1,386

APPENDIX 2

TRAFFIC SIGNAL LAMP INSTALLATION SITES FOR

TEST 1 AND TEST 2

	PAGE NUMBERS
TRAFFIC SIGNAL LAMP	
TEST 1 INSTALLATION SITES .....	2-2 to 2-7
TRAFFIC SIGNAL LAMP	
TEST 2 INSTALLATION SITES .....	2-8 to 2-11
SUMMARY OF CONTROLLER UTILIZATION	
TEST 1 AND TEST 2 .....	2-12

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0304103	Pleasant Valley	38	Moorestown	Burlington	22	2	Crouse Hinds	DM-800	Solid State
0304104	Church	38	Moorestown	Burlington	18	18	Transit	1800	Solid State
0305101	Marter Rd.	38	Mt. Laurel	Burlington	18	0	Econolite	KMC-4000	Microprocessor
0305102	Mt. Holly-Lumberton	38	Lumberton	Burlington	27	0	Econolite	KMC-4000	Microprocessor
0305104	S. Pemberton Rd.	38	Mt. Holly	Burlington	18	18	Data Comm. Sys.	812	Solid State
0305105	Ark Rd.	38	Mt. Laurel	Burlington	12	0	Data Comm. Sys.	812	Solid State
0305108	Hainsport Rd.	38	Hainsport	Burlington	6	12	Data Comm. Sys.	812	Solid State
0305109	Mt. Laurel Rd.	38	Hainsport	Burlington	0	12	Data Comm. Sys.	812	Solid State
0308101	Marlton Pike	38	Medford	Burlington	30	0	Eagle	DP-9000	Solid State
0308102	Jefferson Ward	70	Evesham	Burlington	18	6	Data Comm. Sys.	812	Solid State
0309101	N. Maple Ave.	70	Evesham	Burlington	21	24	Gammatronics	TCN-4400	Solid State
0309102	Hartford Rd.	70	Evesham	Burlington	24	0	Marbelite	MT2SRMP-1SD	Solid State
0309103	Marlton Circle	70-73	Evesham	Burlington	21	0	Eagle	555	Mechanical

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0309104	Cropwell Rd.	70	Evesham	Burlington	34	0	Auto Signal	318	Microprocessor
0309105	Plymouth Dr.	70	Evesham	Burlington	30	24	Econolite	N-2000	Microprocessor
0309106	N. Locust Ave.	70	Evesham	Burlington	24	24	Marbelite	MT2-SRMP	Solid State
0309107	Radnor Blvd.	70	Evesham	Burlington	27	24	Gammatronics	TCN-2200	Solid State
0310101	Huntington Dr.	70	S. Hampton	Burlington	15	12	Marbelite	MT2SRMP-1SD	Solid State
0313102	Church Rd.	73	Mt. Laurel	Burlington	27	6	Crouse Hinds	DM-800	Solid State
0313103	Evesham Rd.	73	Evesham	Burlington	30	0	Data Comm. Sys.	812	Solid State
0313104	Brick Rd.	73	Evesham	Burlington	0	36	Econolite	N-2000	Microprocessor
0313105	Greentree Rd.	73	Mt. Laurel	Burlington	12	30	Econolite	N-2000	Microprocessor
0313107	N. Lincoln Dr.	73	Evesham	Burlington	9	30	Marbelite	MT2SRMP-1SD	Solid State
0313108	S. Lincoln Dr.	73	Evesham	Burlington	9	30	Data Comm. Sys.	812	Solid State
0313109	S. Maple Ave.	73	Evesham	Burlington	12	21	Data Comm. Sys.	812	Solid State
0314101	Fellowship Rd.	73	Maple Shade	Burlington	30	0	Marbelite	MT2SRMP-1SD	Solid State
0314102	Stiles Ave.	73	Maple Shade	Burlington	39	0	Data Comm. Sys.	812	Solid State

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0314103	High St.	73	Maple Shade	Burlington	30	0	Marbelite	MT2SRMP- ISD	Solid State
0314104	Fork Landing	73	Cinnaminson	Burlington	30	0	Data Comm Sys.	812	Solid State
0315101	Tac-Pal Drive- in	73	Palmyra	Burlington	36	0	Marbelite	MT2SRMP- ISD	Solid State
0315102	Sounder St.	73	Palmyra	Burlington	10	0	Marbelite	MT2SRMP- ISD	Solid State
0408101	Mansion Ave.	38	Pennsauken	Camden	0	24	Data Comm Sys.	812	Solid State
0408103	Longwood Ave.	38	Pennsauken	Camden	36	0	Econolite	N-2000	Microprocessor
0408104	Chapel Ave.	38	Cherry Hill	Camden	0	24	Marbelite	MT2SRMP- ISD	Solid State
0408105	Cherry Hill Mall	38	Cherry Hill	Camden	54	18	Crouse Hinds	DM-800	Solid State
0408106	Church & Cole	38	Cherry Hill	Camden	0	24	Auto Signal	527	Solid State
0413102	Cornell Ave.	70	Cherry Hill	Camden	35	9	Auto Signal	314	Microprocessor
0414103	Marlkress Rd.	70	Cherry Hill	Burlington	17	9	Crouse Hinds	DM-400	Solid State
0413104	Edison Ave.	70	Cherry Hill	Camden	36	0	Marbelite	MT2SRMP- ISD	Solid State
0413106	Donahue Ave.	70	Pennsauken	Camden	30	0	Ganmatronics	TCN-2200	Solid State
0413107	McClelland Ave.	70	Pennsauken	Camden	30	0	Data Comm Sys.	812	Solid State
0413108	Lexington Ave.	70	Pennsauken	Camden	42	0	Data Comm Sys.	812	Solid State

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0413109	W. Gate Drive	70	Cherry Hill	Camden	30	0	Crouse Hinds	DM-800	Solid State
0414101	Covered Bridge Rd.	70	Cherry Hill	Camden	33	0	Auto. Signal	527	Solid State
0414102	Springdale Rd.	70	Cherry Hill	Camden	22	6	Crouse Hinds	DM-800	Solid State
0414104	Old Orchard Rd.	70	Cherry Hill	Camden	24	0	Eagle	DP-9000	Microprocessor
0415102	Coopers Folly Rd.	73	Winslow	Camden	33	0	Auto. Signal	527	Solid State
0415103	Jackson Rd.	73	Berlin	Camden	42	0	Eagle	DP-9000	Microprocessor
0415104	Franklin Ave.	73	Berlin	Camden	36	0	Data Comm Sys.	812	Solid State
0416101	Hylton Rd.	73	Pennsauken	Camden	39	0	Econolite	N-2000	Microprocessor
0416102	Remington Ave.	73	Pennsauken	Camden	36	0	Marbelite	MT2SRMP-ISO	Solid State
0431101	Beebe Town Cedar Brook	73	Winslow	Camden	30	0	Data Comm. Sys.	814	Solid State
0431102	Ramp "0"	73	Winslow	Camden	15	0	Marbelite	MT2SRMP-ISO	Solid State
0501101	Ocean Dr.	109	Lower	Cape May	0	34	Crouse Hinds	MD-400	Solid State
0504101	Sea Isle Blvd.	9	Dennis	Cape May	18	15	Marbelite	MT2SRMP-ISO	Solid State
0514101	Stone Harbor Rd.	444	Middle	Cape May	26	18	Auto. Signal	318	Microprocessor

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0514102	Crest Haven Rd.	444	Middle	Cape May	12	21	Data Comm. Sys.	814	Solid State
0517101	Ocean Dr.	147	Middle	Cape May	9	12	Marbelite	MT2SRMP-1SD	Solid State
5836105	Erial New Brooklyn	70	Winslow	Camden	0	24	Flasher	STD	Solid State
0101110	Poplar Ave.	9	Linwood	Atlantic	8	0	Flasher	STD	Solid State
0106103	Cedar Ave.	40	Buena Vista	Atlantic	8	0	Flasher	STD	Solid State
0413103	Grove St. Circle	70	Cherry Hill	Camden	0	5	Flasher	STD	Solid State
0415105	Berlin Traffic Circle	73	Waterford	Camden	8	0	Flasher	STD	Solid State
0510101	Dennisville Rd.	50	Upper	Cape May	12	0	Flasher	STD	Solid State
0604101	Six Corners	49	Shiloh Boro	Cumberland	8	0	Flasher	STD	Solid State
0604107	Barrett Run Rd.	49	Hopewell	Cumberland	8	0	Flasher	STD	Solid State
0608102	Cohanscy-Deerfield	77	Upper	Cumberland	0	8	Flasher	STD	Solid State
0807101	Swedesboro Rd.	45	S. Harrsion	Gloucester	0	8	Flasher	STD	Solid State
0816101	Swedesboro Rd.	77	Elk	Gloucester	8	0	Flasher	STD	Solid State

TRAFFIC SIGNAL LAMPS - TEST 1 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
1702103	Pointers	40	Pilesgrove	Salem	8	0	Flasher	STD	Solid State
1702104	Auburn Rd.	40	Pilesgrove	Salem	8	0	Flasher	STD	Solid State
1703102	Rt. 40 Circle	40&77	Pittsgrove	Salem	8	0	Flasher	STD	Solid State
1703105	Buck Rd.	40	Pittsgrove	Salem	8	0	Flasher	STD	Solid State
1709101	Shirley Rd.	77	Pittsgrove	Salem	8	0	Flasher	STD	Solid State
5836101	Spring Garden	CO.561	Winslow	Camden	8	0	Flasher	STD	Solid State
5836104	Piney Hollow Road	Folsom	Winslow	Camden	8	0	Flasher	STD	Solid State

TRAFFIC SIGNAL LAMPS - TEST 2 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0103109	Indiana Ave.	30	Atlantic City	Atlantic	3	30	Data Comm. Sys.	812	Solid State
0105106	Main Rd.	30	Hammonton	Atlantic	0	30	Transyt	1880	Solid State
0401105	Pinehurst Dr.	30	Waterford	Camden	0	12	Marbelite	MT2	Solid State
0425109	Lower Landing	168	Gloucester	Camden	0	12	Marbelite	MT2	Solid State
0426102	Kings Hwy.	168	Mt. Ephraim	Camden	0	12	Auto. Signal	318	Solid State
0819101	Lakeland	168	Washington	Gloucester	0	12	Data Comm. Sys.	812	Solid State
0426117	Benignd Blvd.	168	Bellmawr	Camden	0	12	Data Comm. Sys.	812	Solid State
0426118	Prospect Ridge	168	Haddon	Camden	0	12	Data Comm. Sys.	812	Solid State
0424104	Bortons Mill	154	Cherry Hill	Camden	0	12	Data Comm. Sys.	812	Solid State
0804101	Clements Bridge	42	Deptford	Gloucester	9	18	Data Comm. Sys.	812	Solid State
0803105	Berlin Crosskeys	42	Washington	Gloucester	7	24	Crouse Hinds	DM 400	Solid State
0803104	Jug Handles	42	Washington	Gloucester	18	24	Crouse Hinds	DM 400	Solid State
0803108	Tuckahoe Rd.	42	Washington	Gloucester	18	21	Data Comm. Sys.	814	Solid State
0803106	Fries Mill	42	Washington	Gloucester	0	18	Marbelite	MT2	Solid State

TRAFFIC SIGNAL LAMPS - TEST 2 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0304103	Pleasant Valley	38	Moorestown	Burlington	22	2	Crouse Hinds	DM-800	Solid State
0305104	S. Pemberton Rd.	38	Moorestown	Burlington	18	18	Data Comm. Sys.	812	Solid State
0305108	Hainsport Rd.	38	Hainsport	Burlington	6	12	Data Comm. Sys.	812	Solid State
0305109	Mt. Laurel Rd.	38	Hainsport	Burlington	0	12	Data Comm. Sys.	812	Solid State
0313109	S. Maple Ave.	73	Evesham	Burlington	30	0	Marbelite	MT2SRMP- ISD	Solid State
0313108	S. Lincoln Dr.	73	Evesham	Burlington	9	30	Data Comm. Sys.	812	Solid State
0313102	Church Rd.	73	Mt. Laurel	Burlington	27	6	Crouse Hinds	DM-800	Solid State
0313104	Brick Rd.	73	Evesham	Burlington	0	36	Econolite	N-2000	Microprocessor
0313105	Green Tree Rd.	73	Mt. Laurel	Burlington	12	30	Econolite	N-2000	Microprocessor
0313107	N. Lincoln Dr.	73	Evesham	Burlington	9	30	Marbelite	MT2SRMP- ISD	Solid State
0310101	Huntington	70	S. Hampton	Burlington	15	12	Marbelite	MT2SRMP- ISD	Solid State
0309107	Radnor Blvd.	70	Evesham	Burlington	27	24	Gammtronics	TCN-2200	Solid State
0309106	N. Locust Ave.	70	Evesham	Burlington	24	24	Marbelite	MT2SRMP	Solid State
0309105	Plymouth Dr.	70	Evesham	Burlington	30	24	Econolite	N-2000	Microprocessor
0309101	N. Maple Ave.	70	Evesham	Burlington	21	24	Gammtronics	TCN-4400	Solid State

TRAFFIC SIGNAL LAMPS - TEST 2 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0403115	Davis Rd.	30	Magnolia	Camden	36	12	Transyt	1880	Solid State
0803107	Ganttown Rd.	42	Washington	Gloucester	17	18	Eagle	DP 9000	Solid State
0803103	Greentree Rd.	42	Washington	Gloucester	0	24	Eagle	DP 9000	Solid State
0403106	Evesham Rd.	30	Magnolia	Camden	0	33	Data Comm.Sys.	814	Solid State
0401107	Waterford-Blue Rd.	30	Winslow	Camden	0	12	Data Comm.Sys.	812	Solid State
0401106	Pump Branch Rd.	30	Winslow	Camden	0	33	Data Comm.Sys.	814	Solid State
0108105	Tilton Rd.	40&332	Egg Harbor	Atlantic	0	21	Gammatronix	TCN 4400	Solid State
0404103	Pine St.	30	Audubon Boro	Camden	24	0	Data Comm.Sys.	812	Solid State
0426112	Callings Ave.	168	Haddon	Camden	27	0	Marbelite	MT 2	Solid State
0507102	Railroad Ave.	47	Middle	Cape May	0	24	Traffic Control Techn.	LC 8000	Solid State
0408101	Mansion Ave.	38	Pennsauken	Camden	0	24	Data Comm. Sys.	812	Solid State
0408104	Chapel	38	Cherry Hill	Camden	0	24	Marbelite	MT2SRMP-ISO	Solid State
0408105	Cherry Hill Mall	38	Cherry Hill	Camden	54	18	Crouse Hinds	DM-800	Solid State
0408106	Church & Cole	38	Cherry Hill	Camden	0	24	Transyt	1880	Solid State
0803102	Whitman Dr.	42	Washington	Gloucester	0	18	Econoline	N2000	Solid State

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TRAFFIC SIGNAL LAMPS - TEST 2 INSTALLATION SITES

CONTROL SECTION NUMBER	INTERSECTING STREET	MAIN RT.	MUNICIPALITY	COUNTY	8" LAMPS USED	12" LAMPS USED	CONTROLLER MANUFACTURER	MODEL NUMBER	CONTROLLER TYPE
0413102	Cornell Ave.	70	Cherry Hill	Camden	35	9	Auto. Signal	314	Microprocessor
0414102	Springdale Rd.	70	Cherry Hill	Camden	22	6	Crouse Hinds	DM-800	Solid State
0414103	Markkress Rd.	70	Cherry Hill	Burlington	17	9	Crouse Hinds	DM-400	Solid State
5836105	Erial New Brooklyn	70	Winslow	Camden	0	24	Data Comm. Sys.	812	Solid State
0517101	Ocean Dr.	147	Middle	Cape May	9	12	Marbelite	MT2SRMP- ISD	Solid State
0514102	Crest Haven Rd.	444	Middle	Cape May	12	21	Data Comm. Sys.	814	Microprocessor
0514101	Stone Harbor Rd.	444	Middle	Cape May	26	18	Auto. Signal	318	Microprocessor
0501101	Ocean Dr.	109	Lower	Cape May	0	34	Crouse Hinds	MD-400	Solid State
0504101	Sea Isle Blvd.	9	Dennis	Cape May	18	15	Marbelite	MT2SRMP- ISD	Solid State

SUMMARY OF CONTROLLER UTILIZATION TEST 1 AND TEST 2

TRAFFIC CONTROLLER USED	MODEL NUMBER	CONTROLLER TYPE	TEST 1 NUMBER USED	TEST 2 NUMBER USED
Auto Signal	314	Microprocessor	1	1
	318	Microprocessor	2	2
	527	Solid State	3	0
Crouse Hinds	DM 800	Solid State	5	4
	DM 400	Solid State	1	3
	MD 400	Solid State	1	1
Data Communication Systems	812	Solid State	14	14
	814	Microprocessor	2	4
Eagle	555	Mechanical	1	0
	DP-9000	Microprocessor	3	2
Econolite	N-2000	Microprocessor	5	4
	KMC-4000	Microprocessor	2	0
Flasher	STD	STD	18	0
Gammatronics	TCN-2200	Solid State	2	1
	TCN-4400	Solid State	1	2
Marbelite	MT2	Solid State	0	4
	MT2-SRMP	Solid State	1	1
	MT2-SRMP- ISD	Solid State	13	6
Traffic Control Technology	LC-8000	Solid State	0	1
Transyt	1800	Solid State	1	0
	1880	Solid State	0	3
TOTAL			<u>76</u>	<u>53</u>

APPENDIX 3

INSTALLATION SHEETS

PAGE NUMBERS

<u>CONTROL SECTION NO.</u>	<u>INTERSECTING STREET</u>	<u>ROUTE</u>	<u>TEST</u>	
1. 0414102	Springdale Road	70	2	3-2
2. 0517101	Ocean Drive-Co.Rt. 30	147	1	3-3
3. 0604107 (Flasher)	Barrett Run Road	49	1	3-4
4. 0803104	N.B. & S.B. Jug Handles	42	2	3-5
5. 0803108	Tuckahoe Road	42	2	3-6
6. 0819101	Turnersville Road Co.Rt. 62	168	2	3-7

DATE 1/24/85

LOCATION ROUTE 70

TIME 3:30 AM PM X

STREET Springdale Road

CONTROL SECTION NUMBER 0414102

Write in the number found on the base of the traffic signal lamp in the block in which it was installed. Install all same letter bulbs in same head. Do not install a lamp in a block which is crossed out.

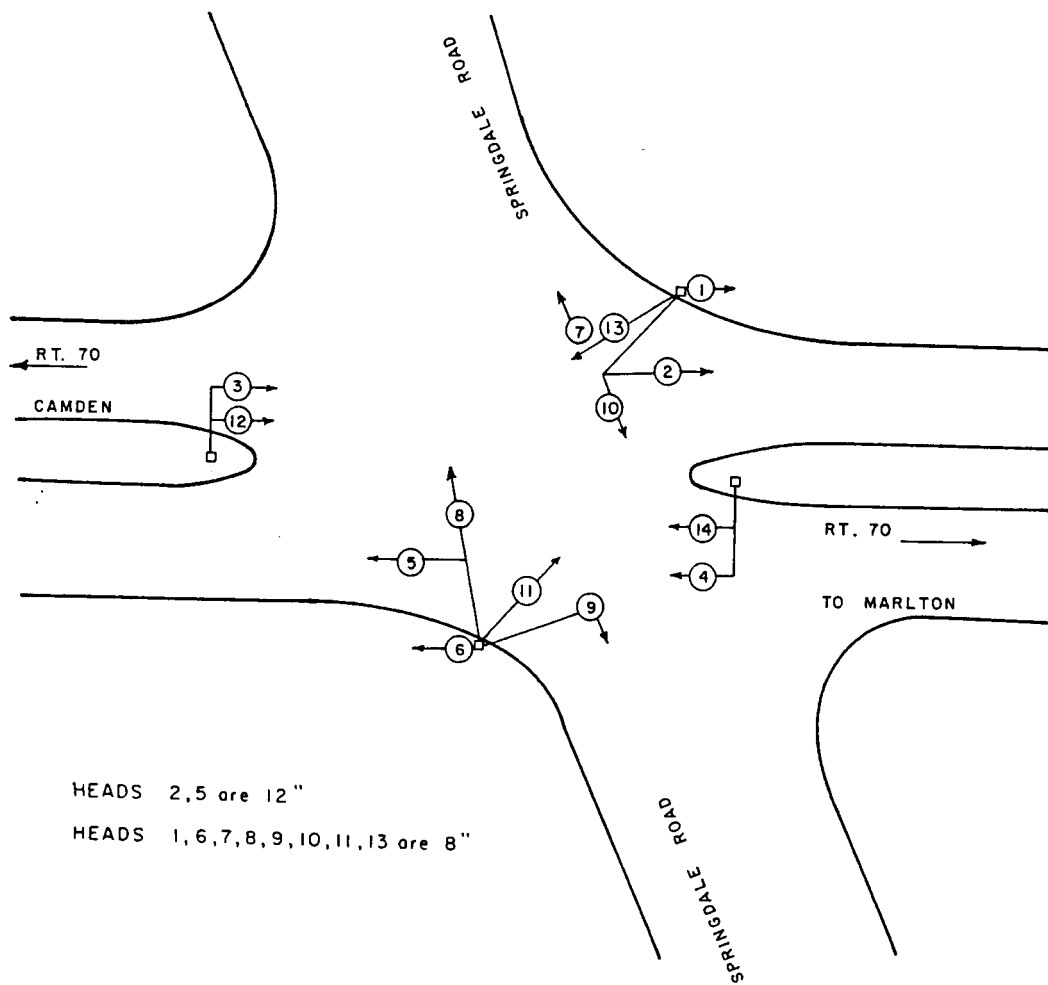
PERSON TO CONTACT C. R. Leininger TELEPHONE NO. 428-6557

KEEP ON COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR, ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6	7	8
RED	1359	951	X	X	396	1365	1380	1335
YELLOW	1358	950	X	X	395	1364	1379	1334
GREEN	1357	949	X	X	394	1363	1378	1333

	9	10	11	12	13	14	15	16
RED	1344	1362	1354	X	1340	X	X	X
YELLOW	1343	1361	1341	X	1339	X	X	X
GREEN	1342	1360	X	X	X	X	X	X



HEADS 2,5 are 12"  
HEADS 1,6,7,8,9,10,11,13 are 8"

DATE 4/13/82

LOCATION: ROUTE Rt. 147

TIME 12:20 AM PM X

STREET Ocean Drive CO Rt. 30

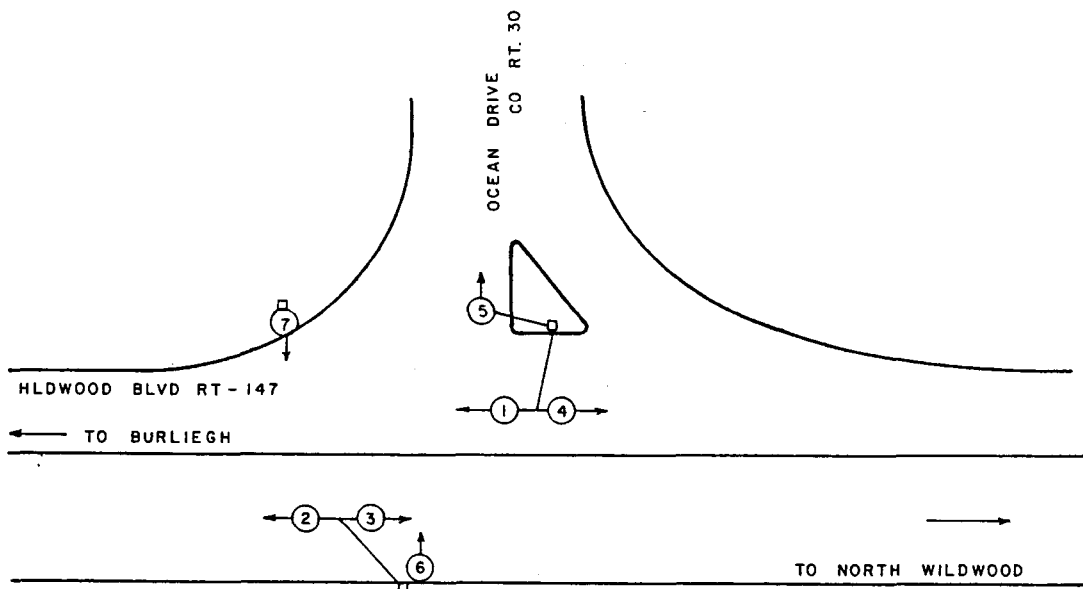
CONTROL SECTION NUMBER 0517101

Write in the number found on the base of the traffic signal lamp in the block in which it was installed. Install all same letter bulbs in same head. Do no install a lamp in a block which is crossed out.

PERSON TO CONTACT David Thompson TELEPHONE NO. 561-1508

KEEP ON COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR, ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6	7	8
RED	DS 226	LS 31	LW 1711	EP 1225	WS 1071	LW 1369	ES 1995	[Crossed out]
YELLOW	DS 227	LS 32	LW 1712	EP 1226	WS 1072	LW 1370	ES 1994	
GREEN	DS 228	LS 33	LW 1713	EP 1227	WS 1073	LW 1371	ES 1993	
	9	10	11	12	13	14	15	16
RED	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]
YELLOW	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]
GREEN	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]	[Crossed out]



HEADS 1,2,3,4 are 12"

HEADS 5,6,7 are 8"

FLASHING SIGNAL LAMP INSTALLATION SHEET

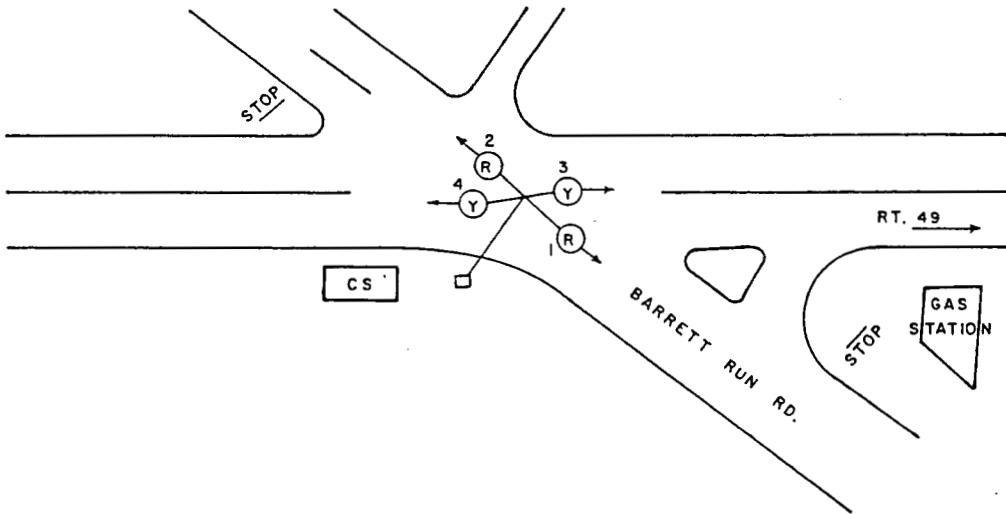
DATE INSTALLED 4/1/82 LOCATION ROUTE 49  
 TIME 1:40 p.m. STREET Barrett Run Road  
 CONTROL SECTION NO. 0604107

Write in number on base of traffic signal lamp in the block in which it was installed. Install different letter lamps in each block. Do not install a lamp in a block which is crossed out.

PERSON TO CONTACT David Thompson TELEPHONE NO. 561-1508

KEEP ONE COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6
R	ES 730	LS 250	Y SS 850	ES 1929	R	
R	ES 1090	DS 370	Y CK 1810	WS 970	R	



Lamps mounted on one pole are 8" programmable. Both reds flash at same time. Red and yellow flash alternately. Light attached with clamp & chain. Lights flash approximately 1 fl./sec. approximately 60 fl./1 min.

DATE 1/23/85 LOCATION ROUTE 42

TIME 12:35 AM PM X STREET N.B. & S.B. Jughandles

CONTROL SECTION NUMBER 0803104

Write in the number found on the base of the traffic signal lamp in the block in which it was installed. Install all same letter bulbs in same head. Do not install a lamp in a block which is crossed out.

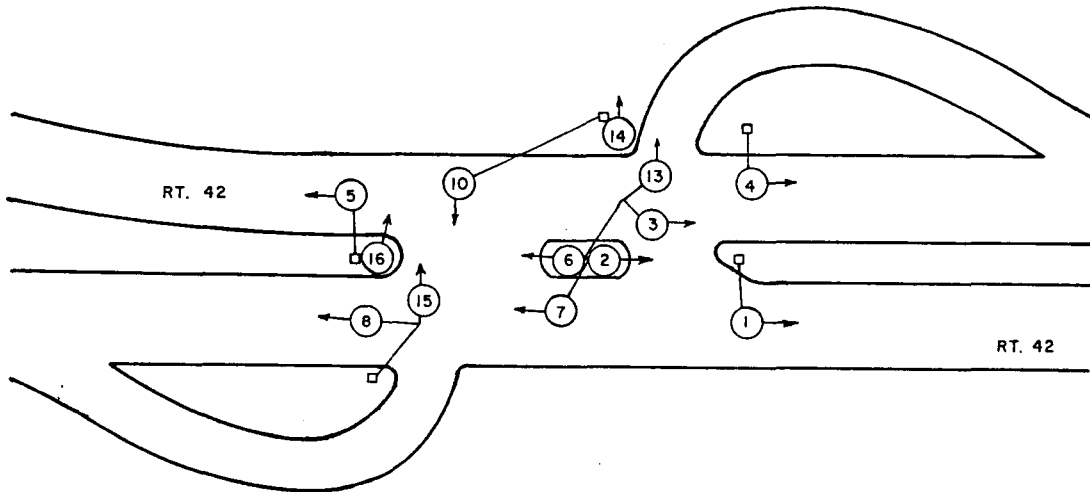
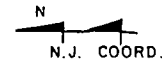
PERSON TO CONTACT D. Thompson TELEPHONE NO. 561-1508

KEEP ON COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR, ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6	7	8
RED	721	49	727	265	52	679	662	724
YELLOW	722	50	728	266	53	680	663	725
GREEN	723	51	729	267	54	681	664	726

	9	10	11	12	13	14	15	16
RED	X	1234	X	X	1207	1222	1213	X
YELLOW	X	1235	X	X	1208	1223	1214	X
GREEN	X	1236	X	X	1209	1224	1215	X



HEADS 1, 2, 3, 4, 5, 6, 7, 8 are 12"

HEADS 10, 13, 14, 15 are 8"

DATE 1/28/85

LOCATION  
ROUTE 42

TIME 9:00 AM X PM

STREET Tuckahoe Road

CONTROL SECTION NUMBER 0803108

Write in the number found on the base of the traffic signal lamp in the block in which it was installed. Install all same letter bulbs in same head. Do not install a lamp in a block which is crossed out.

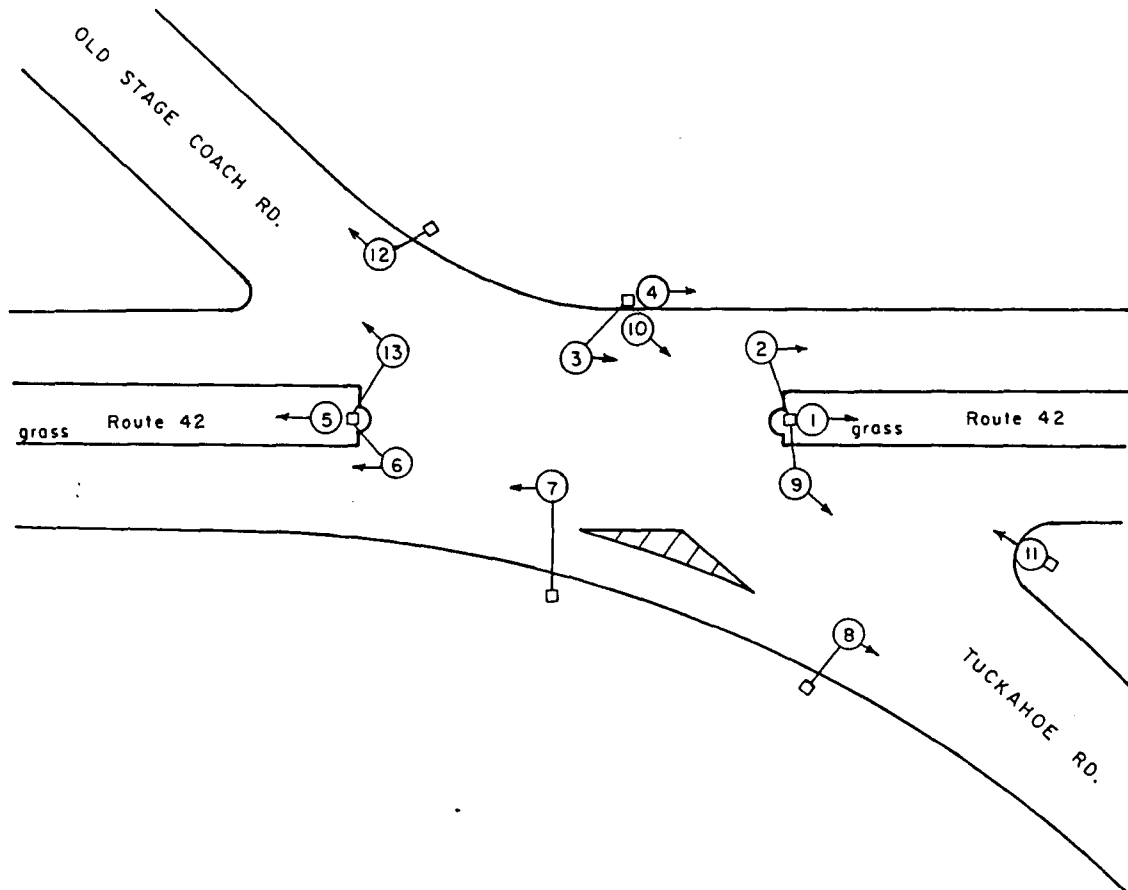
PERSON TO CONTACT D. Thompson TELEPHONE NO. 561-1508

KEEP ON COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR, ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6	7	8
RED	463	229	517	880	511	232	874	1258
YELLOW	464	230	518	881	512	233	875	1259
GREEN	465	231	519	882	513	234	876	1260

	9	10	11	12	13	14	15	16
RED	1201	216	1243	1240	452	X	X	X
YELLOW	1202	217	1244	1241	453	X	X	X
GREEN	1203	218	1245	1242	454	X	X	X



Heads 1,2,3,4,5,6,7,10,13 are 12"

Heads 8,9,11,12 are 8"

DATE 1/23/85 LOCATION  
 ROUTE 168

TIME 10:45 AM X PM STREET Lakeland-Turnersville Rd. (CO 62)

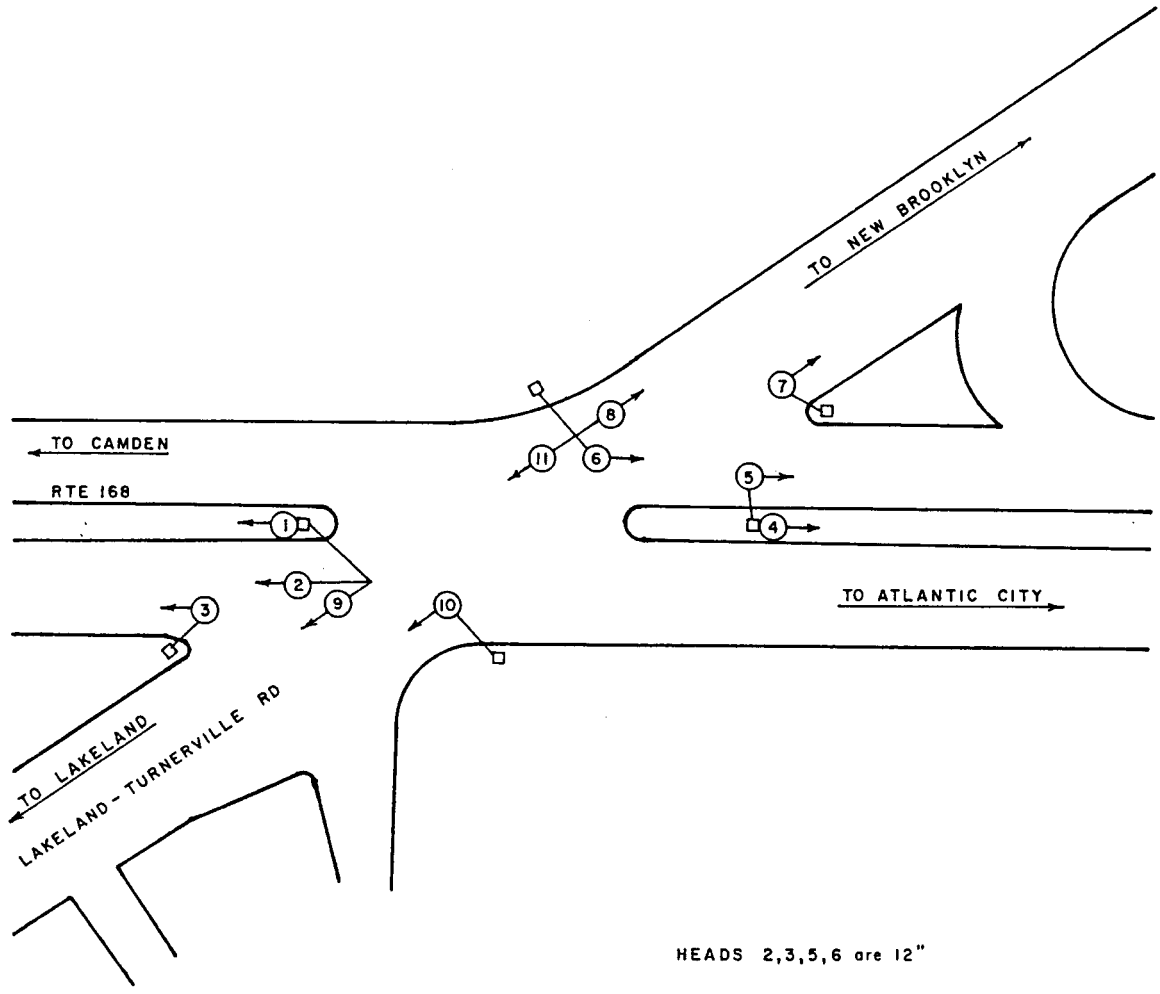
CONTROL SECTION NUMBER 0819101

Write in the number found on the base of the traffic signal lamp in the block in which it was installed. Install all same letter bulbs in same head. Do no install a lamp in a block which is crossed out.

PERSON TO CONTACT D. Thompson TELEPHONE NO. 561-1508

KEEP ON COPY IN M CABINET AND RETURN OTHER ONE TO MR. DICK UTH - DISTRICT SUPERVISOR, ELECTRICAL, CHERRY HILL.

	1	2	3	4	5	6	7	8
RED		685	25		742	244		
YELLOW		686	26		743	245		
GREEN		687	27		744	246		
	9	10	11	12	13	14	15	16
RED								
YELLOW								
GREEN								



APPENDIX 4

INSTALLATION TIMING SHEETS

<u>CONTROL SECTION NO.</u>	<u>INTERSECTING STREET</u>	<u>ROUTE</u>	<u>PAGE NUMBERS</u>
1. 0414102	Springdale Road	70	4-2, to 4-6
2. 0517101	Ocean Drive	147	4-7
3. 0803104	N.B. & S.B. Jug Handles	42	4-8
4. 0803108	Tuckahoe Road	42	4-10, 4-11
5. 0819101	Turnersville Road	168	4-12

Control Section Number 0604107 is a flasher installation. Timing for this intersection is on the bottom of the installation sheet in Appendix 3.

TRAFFIC ENGINEERING - ELECTRICAL PROJECT

Number 369

Job No.	0414102-4701
Memo to	Mrs. D. Andres
Attention	Mr. R. Uth District 4

Route No.	70 & Springdale Road
Location	Cherry Hill Twp., Camden County
Date	December 29, 1986

Due to detector failure for the left turn slots, the following temporary timing and operation should be provided. Upon repair of the detectors, please revert back to directive #50.

AUTHORIZATION: Douglas R. Bartlett (JMP)

Reference:

Date Completed	1-9-87
By	T. Diehl

- Copies: Blue
- Pink
- Green
- White

Original Signed  
 Gerard J. Kerwin

---

TITLE: Chief, Bureau of Electrical Engineeri

Route 70 and Springdale Road  
Cherry Hill Township  
Camden County

**\*\*90 SECOND BACKGROUND CYCLE**

4-3

PHASE	<u>Normal Operation</u>							TIME (SEC.)	OFFSET
	<u>1,2,3</u>	<u>4,5,6</u>	<u>7,8</u>	<u>9,10</u>	<u>11,12</u>	<u>13,14</u>	<u>15,16</u>		
A. Route 70 Change	G Y	G Y	R R	R R	R R	R R	DW DW	45-34 5	40*
B. Springdale Road S/B Change Clearance	R R R	R R R	G Y R	R R R	R R R	R R R	DW DW DW	10-14 4 2	
C. Springdale Road N/B Change Clearance	R R R	R R R	R R R	G Y R	R R R	R R R	DW DW DW	10-12 4 2	
D. Left Turn Slots Change	R R	R R	R R	R R	<-- Y	<-- Y	DW DW	5-10 3	

**With Pedestrian Actuation**

(Phases B and C Shall Not Be Skipped)

A. Route 70 Change	G Y	G Y	R R	R R	R R	R R	DW DW	39-34 5	40*
B. Springdale Road S/B S/B Change and Pedestrian Clearance Clearance	R R R	R R R	G Y R	R R R	R R R	R R R	FW FDW FDW	14 4 2	
C. Springdale Road N/B Change Clearance	R R R	R R R	R R R	G Y R	R R R	R R R	FDW DW DW	12 4 2	
D. Left Turn Slots Change	R R	R R	R R	R R	<-- Y	<-- Y	DW DW	5-10 3	

\*\*120 SECOND BACKGROUND CYCLE

PHASE	<u>Normal Operation</u>							PED. TIME (SEC.)	TIME (SEC.)	OFFSET
	<u>1,2,3</u>	<u>4,5,6</u>	<u>7,8</u>	<u>9,10</u>	<u>11,12</u>	<u>13,14</u>	<u>15,16</u>			
A. Route 70 Change	G Y	G Y	R R	R R	R R	R R	DW DW	- -	75-54 5	54*
B. Springdale Road S/B Change Clearance	R R R	R R R	G Y R	R R R	R R R	R R R	DW DW DW	- - -	10-18 4 2	
C. Springdale Road N/B Change Clearance	R R R	R R R	R R R	G Y R	R R R	R R R	DW DW DW	- - -	10-18 4 2	
D. Left Turn Slots Change	R R	R R	R R	R R	<-- Y	<-- Y	DW DW	- -	5-10 3	

With Pedestrian Actuation and Vehicle Extension  
(Phases B and C Shall Not Be Skipped)

4-4

A. Route 70 Change	G Y	G Y	R R	R R	R R	R R	DW DW	- -	71-54 5	54*
B. Springdale Road S/B S/B Vehicle Extension S/B Change and Pedestrian Clearance Clearance	R R R R	R R R R	G G Y R	R R R R	R R R R	R R R R	FW FDW*** FDW FDW	- 0-4 4 2	71-54 5 0-4 4 2	54*
C. Springdale Road N/B Change Clearance	R R R	R R R	R R R	G Y R	R R R	R R R	FDW DW DW	12-8 - -	10-18**** 4 2	
D. Left Turn Slots Change	R R	R R	R R	R R	<-- Y	<-- Y	DW DW	- -	5-10 3	

\*\*\*FDW to begin at termination of FW and will guarantee FDW for 18 seconds.

\*\*\*\*This interval can have its green time extended from 1 to 10 seconds upon termination of the flashing "DON'T WALK" if vehicle actuations occur.

Route 70 and Springdale Road  
Cherry Hill Township, Camden County  
Camden County

Memory circuit on phase B is connected.

Memory circuit on phases C and D are disconnected.

Vehicle interval on phase B is 4 seconds.

Vehicle interval on phases C and D is 2 seconds.

Minimum recall on phase C.

The manual control is to remain connected.

The recall switch for phase A be left in the "ON" position. Recall switches for phases B, C, and D be left in the "OFF" position.

The controller skip phases which are not actuated.

The left turn slots (phase D) be separate phases but concurrently timed if actuation occurs in both slots.

Each left turn slot has the capability of terminating or extending independently of each other, thereby reverting the timing to the non-conflicting phase A movement.

EMERGENCY FLASHING OPERATION: Flash yellow to Route 70 and flash red to Springdale Road and left turn slot signals for Route 70. The pedestrian signals are to be DARK.

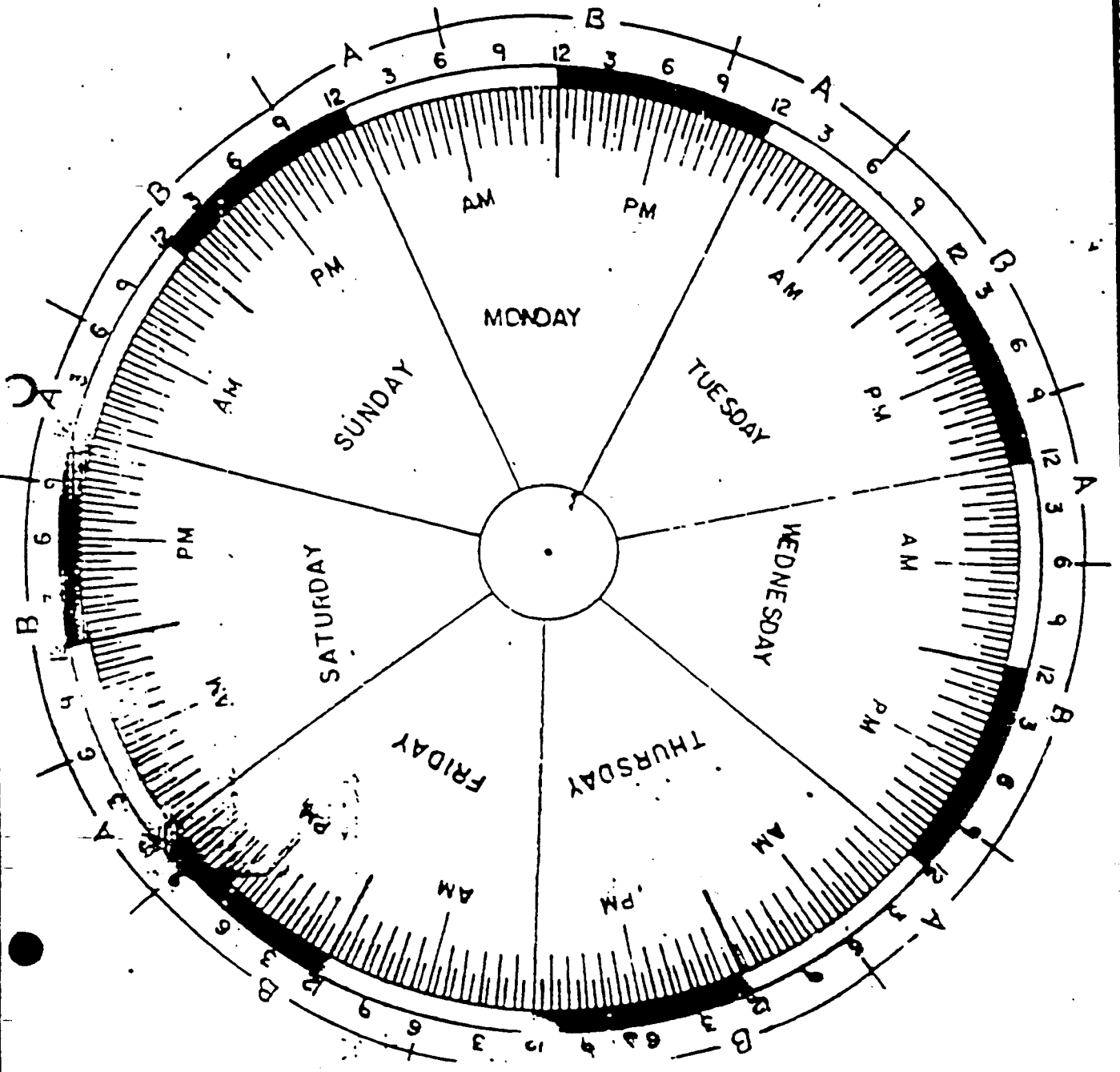
\*Offset measured from the beginning of yellow to Route 70 traffic at Marlkrass Road to the beginning of yellow to Route 70 traffic at this intersection.

\*\*Refer to the attached time clock dial diagram which indicates the days and hours of operation.

OF DIAL OF 7 DAY  
CLOCK SHOWING SETTINGS  
TO BE USED.

LOCATION: ROUTE NJ 70  
SPRINGBLE ROAD  
MUNICIPALITY CHEERY HILL TOWNSHIP  
COUNTY CAMDEN  
DATE 6/14/84 FILE NO. 0409

"A" - 90" BACKGROUND CYCLE (9PM-6AM DAILY) 9"  
"B" - 120" " (6AM-9PM DAILY) 15"



**TRAFFIC ENGINEERING - ELECTRICAL PROJECT**

Number 28

Job No.	0517101-4651
Memo to	Mr. R. Uth - District 4
Attention	

Route No.	147 and Ocean Dr. (Co.Rd.30)
Location	Middle Twp., Cape May County
Date	July 28, 1977

Please employ your State forces to perform the following work at the above captioned intersection as recommended by our Traffic Bureau:

1. Install a semi-actuated traffic signal with pedestrian pushbuttons as shown.
2. Install areas of presence detection as shown.
3. Equip signal heads #1-4 with 12" indications.
4. Mount signal head #6 at 12'.
5. Remove the existing signal equipment.
6. Employ the following signal timing and operation:

May 1 to October 1

59-72 Second Variable Cycle

	<u>Green</u>	<u>Yellow</u>	<u>Red</u>
Route 147	40	5	14-27
Ocean Drive	10-23	4	45

October 1 to May 1

41-57 Second Variable Cycle

	<u>Green</u>	<u>Yellow</u>	<u>Red</u>
Route 147	25	5	11-27
Ocean Drive	7-23	4	30

As actuation of a pedestrian pushbutton will provide a minimum green time of 10 seconds to Ocean Drive.

Vehicle Interval: 2 seconds

Manual control be disconnected.

Memory circuit be disconnected.

Reference:

Mr. D. Hartig's memo dated January 24, 1977  
cc: Mr. R. Nolan

Date Completed	
By	

- Copies: Blue  
Pink  
Green  
White

TITLE: Chief, Bureau of Electrical Operations

**TRAFFIC ENGINEERING - ELECTRICAL PROJECT**

Number 487

Job No.	0803104-4701
Memo to	Mr. Jack Dunn
Attention	Mr. R. Uth, District 4

Route No.	42 & Station 742 (Bus Turnout)
Location	Washington Twp., Gloucester County
Date	January 31, 1986

Due to the revisions to the signal at this intersection, it is necessary that the temporary timing and operation as shown on the attached sheet be employed.

AUTHORIZATION: Douglas R. Bartlett (MPM)

Reference:

Date Completed	2-7-86
By	

Copies: Blue  
Pink  
Green  
White

---

TITLE: Chief, Bureau of Electrical Engineerin

120 SECOND-BACKGROUND-CYCLE

SIGNAL FACES

<u>PHASE</u>	<u>1,2,3,4</u> <u>5,6,7,8</u>	<u>10,11</u> <u>13,14</u>	<u>15,16</u>	<u>TIME(SEC.)</u>
A. Route 42	G	R	R	87-74
Change	Y	R	R	6*
Clearance	R	R	R	2
B. N/B and S/B Jughandles	R	G	R	8-21**
Change	R	Y	R	3
Clearance	R	R	R	2
C. Bus Garage	R	R	G	7
Change	R	R	Y	3
Clearance	R	R	R	2

\*Offset is 8 seconds as measured from the beginning of yellow to Route 42 traffic at Greentree Road, to the Beginning of yellow to Route 42 traffic at this intersection.

\*\* An actuation of pedestrian pushbutton is to be guarantee 18 seconds of green time to Phase B.

The manual control is to be disconnected.

The memory circuit is to be disconnected and the vehicle interval is to be set at 2 seconds for Phase B.

The signal is to be capable of shipping any unactuated phases.

Phase C is to be placed on minimum recall.

Upon completion of the revisions, the timing and operation should, as set forth in Directive #532, dated April 17, 1980, be employed.

**TRAFFIC ENGINEERING - ELECTRICAL PROJECT**

Number 806

Job No.	0803108-4701
Memo to	Mrs. D. Andres
Attention	Mr. R. Uth, District 4

Route No.	42 & Tuckahoe Road
Location	Washington Twp., Gloucester County
Date	

Please employ the following temporary traffic signal timing and operation as shown on the attached sheet.

AUTHORIZATION: Douglas R. Bartlett (MPM)

Reference:

Date Completed	6-18-86
By	

- Copies: Blue
- Pink
- Green
- White

---

TITLE: Chief, Bureau of Electrical Engineering

96-101 SECOND VARIABLE CYCLE

Signal Faces

<u>PHASE</u>	<u>1,2,3, 4,5,6,7</u>	<u>8,9,10</u>	<u>11,12,13</u>	<u>TIME (SEC.)</u>
A. Route 42	G	R	R	45
Change	Y	R	R	6
Clearance	R	R	R	2
B. Tuckahoe Road	R	G	R	20
Change	R	Y	R	5
Clearance	R	R	R	3
C. Old State Coach Road	R	R	G	7*-12
Change	R	R	Y	5
Clearance	R	R	R	3

\*Actuation of a pedestrian pushbutton is to guarantee a minimum of 10 seconds green time to Phases B and C.

Any unactuated phases to be skipped.

The memory circuit is to be disconnected.

The vehicle interval is to be set at 2 seconds.

The manual control is to be connected.

Upon completion of repairs to the detectors, the timing and operation as set forth in Directive #471, dated January 9, 1986, is to be re-employed.

**TRAFFIC ENGINEERING - ELECTRICAL PROJECT**

Number 37

Job No.	0819101-4701
Memo to	Mr. Jack Dunn
Attention	Mr. R. Uth, District 4

Route No.	168 & Lakeland-Turnersville Road
Location	Washington Twp., Gloucester County
Date	August 15, 1984

Please maintain the following signal timing and operation:

55-77 Second Variable Cycle

	<u>Green</u>	<u>Yellow</u>	<u>All Red</u>	<u>Red</u>
Route 168	35	5	0	17-37
Lakeland-Turnersville Rd. 10-30	4	3	40	

The manual control is to be disconnected.

The memory circuit is to be disconnected and the vehicle extension is to be set at two (2) seconds.

An actuation of a pedestrian pushbutton is to guarantee Lakeland-Turnersville Road 30 seconds of green without causing recall to the side street.

AUTHORIZATION: James L. Kochenour (MPM)

Reference:

Date Completed	
By	

- Copies: Blue
- Pink
- Green
- White

\_\_\_\_\_

TITLE: Chief, Bureau of Electrical Engineering

APPENDIX 5

BURNOUT SHEET

TRAFFIC SIGNAL LAMP OR FLASHER SIGNAL LAMP

BURNOUT SHEET

DATE 3/7/85

TIME 12:30 pm

LOCATION - ROUTE 70

- STREET 73

- CONTROL SECTION NUMBER 0309103

SIGNAL HEAD NUMBER OR FLASHER HEAD NUMBER (refer to copy of the installation sheet in the cabinet)

SIGNAL HEAD NUMBER

FLASPER HEAD NUMBER

#18

\_\_\_\_\_

RED

--

R\_\_orY\_\_

--

YELLOW

--

R\_\_orY\_\_

--

GREEN

SS958
-------

Record the number that is on the base of the burned out traffic signal lamp in the block from which it was removed. Record date of removal near box on installation sheet.

Size of Lens (8 inch or 12 inch) 8"

Condition of reflector and lens from which burned lamp was removed

dirty \_\_\_\_\_ discolored \_\_\_\_\_

water has leaked in \_\_\_\_\_ other Good

The lamp housing is considered to be O. K. if nothing is checked or noted.

NAME OF PERSON Richard Uth TELEPHONE NO. 428-6557  
TO CONTACT \_\_\_\_\_

RETURN THIS SHEET AND THE TRAFFIC SIGNAL LAMP TO MR. DICK UTH, DISTRICT SUPERVISOR ELECTRICAL - CHERRY HILL

APPENDIX 6

SIGNAL HEAD TIMING SHEETS  
AND TIMING CALCULATIONS

	PAGE NUMBERS
1. INTRODUCTION .....	6-2
2. SIGNAL HEAD TIMING SHEET FIELD DESCRIPTIONS .....	6-4
3. SIGNAL HEAD TIMING SHEET .....	6-7

<u>Control Section No.</u>	<u>Intersecting Street</u>	<u>Route</u>
1. 0414102	Springdale Road	70
2. 0517101	Ocean Drive	147
3. 0803104	N.B. & S.B. Jug Handles	42
4. 0803108	Tuckahoe Road	42
5. 0819101	Turnersville Road	168

4. TIMING CALCULATIONS FOR CONTROL SECTION 0309106 .....	6-13
5. FLASHER INSTALLATION TIMING .....	6-15
6. TIMING DBASE FILES FOR TEST 1 AND TEST 2 .....	6-16

## INTRODUCTION

This Appendix contains information used in determining the total number of on/off cycles and total number of on-hours that the test lamps experienced during a twenty-four hour period in Test 1 and Test 2.

Signal head timing sheets in this Appendix were used to organize data obtained from the installtion timing sheets in Appendix 4.

The signal head timing sheet contains the average seconds per cycle per signal face for the main street and side streets, the signal head numbers, and total average cycles per twenty-one hour day.

The data in this sheet is used by a microcomputer program (TIMING.PRG, discussed in Appendix 7), to calculate total average on-hours and total average cycles for each lamp for the days installed. Descriptions of signal head timing sheet fields begins on page 6-4. Signal head timing sheets are on pages 6-7 to 6-12 and corresponds to the installation sheets and installation timing sheets in Appendices 3 and 4. Timing calculations for control section 0309106, that begins on page 6-13, was selected to show the steps in completing the data fields contained in the signal head timing sheet on page 6-14.

Timing for all flasher installations is found on page 6-15. Test 1 included eighteen flasher installations. Flashers were not included in Test 2.

The data taken from the installation timing sheets for the fields "CONTROL SECTION #," "MAIN ST," "SIDE ST," "AVG SEC.," "TOTAL AVERAGE CYC. PER DAY" and the lens color is placed into a data base called "TIMING" shown on page 6-16. This data base is used by the timing program in Appendix 7 to calculate the fields "TOTAL AVERAGE HOURS" and "TOTAL AVERAGE CYCLES" for Test 1 and Test 2 master data bases.

The first page of the timing dbase file for Test 1 is on page 6-16 and on page 6-17 for Test 2. Only the first page of data are included for each test.

SIGNAL HEAD TIMING SHEET FIELD DESCRIPTIONS

FIELD NAME

DESCRIPTION

CONTROL SECTION #

Identifying number located on traffic signal controller cabinet. This number corresponds to the intersection location, and is contained on drawings, timing sheets, installation sheets, etc.

TOTAL AVERAGE  
CYC. PER DAY

This number is the total number of on/off cycles that the lamps in the intersection experience in a 21 hour day. The 21 hours is an average time and is based on a minimum cycle time of 18 hours and a maximum cycle time of 24 hours per day. It is assumed that the intersection on the average does not continuously cycle in the early morning hours. The red on the side road and the green on the main road remain on unless activated by traffic. For intersections with a variable cycle time, the two cycle times are added together then averaged. The length of a single cycle in seconds is taken from the installation timing sheets in Appendix 4.

MAIN ST. Listed are signal head numbers facing the main street.

SIDE ST. Listed are signal head numbers facing the side street.

HEADNUMB Listed are head numbers for which the signal head timing applies.

MIN SEC. Minimum number of seconds a lamp was on per cycle. MIN SEC. was used only on installations with variable cycles.

MAX. SEC. Maximum number of seconds a lamp was on per cycle. MAX. SEC. was only used on installations with variable cycles.

AVG SEC. The value in this field is either the number of seconds the lamp was on or an average of the minimum and maximum seconds.

R Red signal face

Y Yellow signal face

G Green signal face

The next six pages are signal head timing sheets used in Test 1 and Test 2. These were used to arrive at the total number of cycles and total average on-hours experienced by each test lamp.

SIGNAL HEAD TIMING SHEET

CONTROL SECTION #: 0414102

TOTAL AVERAGE CYC PER DAY: 840

MAIN ST. HEADNUMB 1,2

SIDE ST. HEADNUMB 5,6

ROUTE # 70

STREET: Springdale

MIN SEC. MAX SEC. AVG SEC.

R	36	51	43.5
Y			5
G	34	49	41.5
			90

MIN SEC. MAX SEC. AVG SEC.

R	36	51	43.5
Y			5
G	34	49	41.5
			90

HEADNUMB 7,8

HEADNUMB 9,10

MIN SEC MAX SEC AVG SEC.

R	72	78	75
Y			4
G	9	14	11
			90

MIN SEC. MAX SEC. AVG SEC.

R	74	78	76
Y			4
G	8	12	10
			90

NOTE: Some intersections have multiple timings. These are designated as M, M1, and S, S1, S2 in the data base to account for these multiple timings for the main street and the side streets. This control section, 0414102, has two signal head timing sheets because of multiple timings.

**SIGNAL HEAD TIMING SHEET**

CONTROL SECTION #: 0414102 continued

TOTAL AVERAGE CYC PER DAY: 840

MAIN ST. HEADNUMB 11,12

SIDE ST. HEADNUMB 13,14

ROUTE # 70

STREET: Springdale

MIN SEC. MAX SEC. AVG SEC.

R	77	82	79.5
Y			3
G			7.5
			90

MIN SEC. MAX SEC. AVG SEC.

R	77	82	79.5
Y			3
G			7.5
			90

HEADNUMB \_\_\_\_\_

MIN SEC MAX SEC AVG SEC.

R			
Y			
G			

HEADNUMB \_\_\_\_\_

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

**SIGNAL HEAD TIMING SHEET**

CONTROL SECTION #: 0517101

TOTAL AVERAGE CYC PER DAY: 1321

MAIN ST. HEADNUMB 1-4

SIDE ST. HEADNUMB 5-7

ROUTE # 147

STREET: Ocean Drive

MIN SEC. MAX SEC. AVG SEC.

R	12.5	27	19.75
Y			5
G	25	40	32.5
			57.25

MIN SEC. MAX SEC. AVG SEC.

R	30	45	37.5
Y			4
G	8.5	23	15.75
			57.25

HEADNUMB \_\_\_\_\_

MIN SEC MAX SEC AVG SEC.

R			
Y			
G			

HEADNUMB \_\_\_\_\_

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

SIGNAL HEAD TIMING SHEET

CONTROL SECTION #: 0803104

TOTAL AVERAGE CYC PER DAY: 630

MAIN ST. HEADNUMB 1-8

SIDE ST. HEADNUMB 10,13,14

ROUTE # 42

STREET: N.B. & S.B. Jug Handles

MIN SEC. MAX SEC. AVG SEC.

R	27	40	33.5
Y			6
G	74	87	80.5
			120

MIN SEC. MAX SEC. AVG SEC.

R	96	109	102.5
Y			3
G	8	21	14.5
			120

HEADNUMB 15

MIN SEC MAX SEC AVG SEC.

R	97	123	110
Y			3
G			7
			120

HEADNUMB \_\_\_\_\_

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

SIGNAL HEAD TIMING SHEET

CONTROL SECTION #: 0803108

TOTAL AVERAGE CYC PER DAY: 767.5

MAIN ST. HEADNUMB 1-7

SIDE ST. HEADNUMB 8-10

ROUTE # 42

STREET: Tuckhoe

MIN SEC. MAX SEC. AVG SEC.

R	45	50	47.5
Y			6
G			45
			98.5

MIN SEC. MAX SEC. AVG SEC.

R	71	76	73.5
Y			5
G			20
			98.5

HEADNUMB 11-13

HEADNUMB \_\_\_\_\_

MIN SEC MAX SEC AVG SEC.

R			84
Y			5
G			9.5
			98.5

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

**SIGNAL HEAD TIMING SHEET**

CONTROL SECTION #: 0819101

TOTAL AVERAGE CYC PER DAY: 1128.4

MAIN ST. HEADNUMB 2,3,5,6

SIDE ST. HEADNUMB \_\_\_\_\_

ROUTE # 168

STREET: Turnersville

MIN SEC. MAX SEC. AVG SEC.

R	17	37	27
Y			5
G			35
			67

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

HEADNUMB \_\_\_\_\_

MIN SEC MAX SEC AVG SEC.

R			
Y			
G			

HEADNUMB \_\_\_\_\_

MIN SEC. MAX SEC. AVG SEC.

R			
Y			
G			

TIMING CALCULATIONS FOR CONTROL SECTION 0309106

The table listed below was taken from the installation timing sheet for control section 0309106. The numbers below each signal face color represents the time in seconds that each signal lamp is on during a background cycle.

	<u>Head No.</u>	<u>Ped.</u>	<u>Green</u>	<u>Yellow</u>	<u>All Red</u>	<u>Red</u>
Rt. 70	1-10	-	72-55	6	0	12-29
Locust St.	11-16	11	7-24	3	2	78-61

This intersection has a "90 second background cycle." It takes 90 seconds to complete one on/off cycle.

Total average cycles are determined by dividing the number of seconds in a twenty-one hour day by 90 seconds. An intersection was assumed to cycle 21 hours per day. This is the average of 18 hours and 24 hours.

Three hours were added to the on-time per day to each of the lamps in the green signal faces on the main road and three hours were added to the on time per day to each of the lamps in the red signal faces on the side road to account for the time that the intersection on the average did not cycle.

SIGNAL HEAD TIMING SHEET

CONTROL SECTION #: 0309106

TOTAL AVERAGE CYC PER DAY: 840

MAIN ST. HEADNUMB 1-10

SIDE ST. HEADNUMB 11-16

ROUTE # 70

STREET: N. Locust Avenue

MIN SEC. MAX SEC. AVG SEC.

MIN SEC. MAX SEC. AVG SEC.

R	12	29	20.5
Y	6	6	6
G	55	72	63.5
			90.0

R	63	80	71.5
Y	3	3	3
G	7	24	15.5
			90.0

All the numbers in the minimum seconds and maximum seconds fields shown in the above signal head timing sheet were taken from the Table on page 6-13.

"MIN SEC" and "MAX SEC" was used to determine the "AVG SEC" per cycle.

The values in the "AVG SEC" column from this sheet is entered into the "Timing" data base. This data base is used in calculating "Total Average Hours" and "Total Average Cycles" in the master dbase file using the program "Timing.Prg." For a complete description of this program see Appendix 7.

## FLASHER INSTALLATION TIMING

A flasher installation sheet for control section 0604107 is on page 3-4 of Appendix 3, "Installation Sheets." The flasher timing at the bottom of page 3-4 is for all flasher installations used in Test 1. Flasher installations were not used in Test 2.

Traffic signal lamps in a flasher installation cycle on and off once a second, twenty-four hours a day. The traffic signal lamp is assumed to be on (filament temperature above a nominal value where filament evaporation takes place) for 0.5 seconds per one second cycle or 43,200 seconds per day.

TIMING DBASE FILE  
TEST 1

CONTROL SECTION NUMBER	MAIN OR SIDE STREET	LENS COLOR	TOTAL AVERAGE SECONDS PER CYCLE	TOTAL AVERAGE CYCLES PER DAY
0304103	M	R	38.00	840.00
0304103	M	Y	5.00	840.00
0304103	M	G	47.00	840.00
0304103	S	R	77.00	840.00
0304103	S	Y	3.00	840.00
0304103	S	G	10.00	840.00
0304104	M	R	30.00	840.00
0304104	M	Y	5.00	840.00
0304104	M	G	55.00	840.00
0305101	M	R	31.00	840.00
0305101	M	Y	5.00	840.00
0305101	M	G	54.00	840.00
0305102	M	R	36.50	840.00
0305102	M	Y	5.00	840.00
0305102	M	G	48.50	840.00
0305102	S	R	63.50	840.00
0305102	S	Y	4.00	840.00
0305102	S	G	22.50	840.00
0305104	M	R	24.00	840.00
0305104	M	Y	5.00	840.00
0305104	M	G	61.00	840.00
0305104	S	R	68.00	840.00
0305104	S	Y	3.00	840.00
0305104	S	G	19.00	840.00
0305105	M	R	26.00	840.00
0305105	M	Y	5.00	840.00
0305105	M	G	59.00	840.00
0305108	M	R	17.50	1190.50
0305108	M	Y	6.00	1190.50
0305108	M	G	40.00	1190.50
0305109	M	R	21.50	1120.00
0305109	M	Y	6.00	1120.00
0305109	M	G	40.00	1120.00
0308101	M	R	37.50	840.00
0308101	M	Y	6.00	840.00
0308101	M	G	46.50	840.00
0308101	S	R	70.50	840.00
0308101	S	Y	3.00	840.00
0308101	S	G	16.50	840.00
0308101	S1	R	76.00	840.00
0308101	S1	Y	3.00	840.00
0308101	S1	G	11.00	840.00
0308102	M	R	22.50	840.00
0308102	M	Y	6.00	840.00
0308102	M	G	61.50	840.00
0308102	S	R	69.50	840.00
0308102	S	Y	3.00	840.00
0308102	S	G	17.50	840.00
0308102	M	R	22.50	840.00

TIMING DBASE FILE  
TEST 2

CONTROL SECTION NUMBER	MAIN OR SIDE STREET	LENS COLOR	TOTAL AVERAGE SECONDS PER CYCLE	TOTAL AVERAGE CYCLES PER DAY
0103109	M	R	19.00	840.00
0103109	M	Y	4.00	840.00
0103109	M	G	67.00	840.00
0103109	S	R	75.00	840.00
0103109	S	Y	3.00	840.00
0103109	S	G	12.00	840.00
0105106	M	R	38.50	672.00
0105106	M	Y	5.00	672.00
0105106	M	G	46.50	672.00
0108105	M	R	51.50	849.40
0108105	M	Y	5.00	849.40
0108105	M	G	32.50	849.40
0108105	S	R	36.00	849.40
0108105	S	Y	5.00	849.40
0108105	S	G	49.00	849.40
0108105	S1	R	59.00	849.40
0108105	S1	Y	4.00	849.40
0108105	S1	G	26.00	849.40
0304103	M	R	38.00	840.00
0304103	M	Y	5.00	840.00
0304103	M	G	47.00	840.00
0305108	M	R	17.50	1190.50
0305108	M	Y	6.00	1190.50
0305108	M	G	40.00	1190.50
0305109	M	R	21.50	1120.00
0305109	M	Y	6.00	1120.00
0305109	M	G	40.00	1120.00
0309101	M	R	38.00	840.00
0309101	M	Y	6.00	840.00
0309101	M	Y	6.00	840.00
0309101	M	Y	6.00	840.00
0309101	M	G	46.00	840.00
0309101	S	R	56.00	840.00
0309101	S	Y	4.00	840.00
0309101	S	G	30.00	840.00
0309105	M	R	21.50	840.00
0309105	M	Y	6.00	840.00
0309105	M	G	62.50	840.00
0309105	S	R	72.50	840.00
0309105	S	Y	3.00	840.00
0309105	S	G	14.50	840.00
0309106	M	R	20.50	840.00
0309106	M	Y	6.00	840.00
0309106	M	G	63.50	840.00
0309106	S	R	71.50	840.00
0309106	S	Y	32.00	840.00
0309106	S	G	15.50	840.00
0309107	M	R	20.50	840.00
0309107	M	Y	6.00	840.00

APPENDIX 7

MICROCOMPUTER dBASE AND SAS PROGRAMS

FOR TEST 1 AND TEST 2

	PAGE NUMBERS
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2. MASTER dBASE FIELD NAME DESCRIPTIONS FOR TEST 1 AND TEST 2 LAMP DATA .....	7-3
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## INTRODUCTION

The master data base structure and microcomputer programs for the processing and analysis of lamp data from Test 1 and Test 2 are described. Basic software packages used were Ashton Tate's dbase III Plus and SAS\* a statistical analysis system. Dbase programs were written for the timing calculations for the fields "Total Average Hours" and "Total Average Cycles" in the master data base. SAS programs were written to calculate accumulated percent burnouts and to plot the figures in Appendix 11.

\*SAS Insitute Inc.  
SAS Circle, Box 8000  
Cary, North Carolina 27512-8000

MASTER DATA BASE STRUCTURE AND FIELD DESCRIPTION

FOR TEST 1 AND TEST 2 - LAMP DATA

<u>Field Name</u>	<u>Field Description</u>
1. Lmpuncount	True/False, Lamp not accounted for at end of the test
2. Bulbno	Lamp alphanumeric base code
3. Headnumb	Signal head number in the inter- section
4. Color	Color of the signal face lens behind which the lamp is installed, red/yellow/or green
5. MainRoute	Main route number at the inter- section
6. Ctrlsecno	State coded intersection number
7. Volts	Rated voltage of the lamp
8. Watts	Rated wattage of the lamp
9. Supports	Number of filament supports in the lamp. Power leads are not counted as filament supports.
10. Instal-Date	Date the lamp was installed
11. Remov-Date	Date the lamp was removed
12. Days-In	Number of days lamp was installed
13. Burnout	True/False, lamp burned out
14. Knockdown	True/False, lamp was knocked down

15. Relamp	True/False lamp was accidentally replaced during group relamping or because of a signal revision
16. Found-Type	Type of the foundation used for pole base
17. Found-Loca	Location of the foundation
18. Pole-Base	Type of pole base used
19. Pole-Type	Type of pole used
20. Arm-Length	Length of mast arm
21. Head-attch	Type of connector used to attach signal head to the mast arm
22. Head-Toget	Number of signal heads attached together
23. Road Type	Type of roadway surface
24. Road-Cond	Roadway surface condition
25. Soil-Type	Type of soil in area
26. Bulb-Supp	How lamp was obtained complimentary or purchased
27. Burn-Posit	Burning position clocked after removal
28. Main-Side	M/S, lamp installed on main street or side road
29. Interstret	Name of intersecting street
30. Municipal	Municipality in which intersection is located
31. County	County in which intersection is located

32. Lamp-Manuf	Name of the lamp manufacturer
33. Lamp-Type	Type of lamp krypton, standard, thermistor
34. Age	New-recently manufactured. Old-in stock more than six months.
35. Typ-contro	Type of signal controller used mechanical/solid state/ microprocessor
36. Contrmanfc	Signal controller manufacturer
37. Brokinship	True/False, lamp broken in shipment
38. Brokebinst	True/False, lamp broken before installation
39. Brokatinst	True/False, lamp broken at installation
40. Vandelism	True/False, signal shot out (lamp broken)
41. Smoke	True/False, lamp smoked upon installation and burned out
42. Leaker	True/False, lamp burned out early because oxygen leaked into lamp
43. Carbon	Evidence of carbon on inside of lamp
44. Damheaseal	True/False lamp burned out as a result of signal head leaking in water

45. Fillagood	True/False, filament continuous
46. Fillabroke	True/False, filament broken
47. Fillastrec	True/False filament stretched
48. SFCTOGETH	Signal head numbers that are cycled together
49. Totalavghr	Total average hours that the lamp was on during its installation life
50. Totalavgcy	Total average cycles that the lamp experienced during its installation life
51. Modelnumb	Controller model number
52. Headsused	Signal head numbers used for a given intersection

## TIMING PROGRAM AND DESCRIPTION

The timing program calculates total average on hours and total average cycles that test lamps experienced during their installation lifetimes for both Test 1 and Test 2.

Records from both the master dbase and the timing dbase files (in Appendix 6) are sorted by control section number, main or side street, and by lens color. The timing dbase file contains the control section numbers, main or side street designation, lens color, total average seconds per cycle and total average cycles per day. The control section number, lens color and street is stored in memory. The computer program then searches for matching information in the master file. When a match is found the program then calculates the total average on-hours and the total average cycles for each lamp using the fields "Total Average Seconds Per Cycle" and "Total Average Cycles Per Day" from the timing dbase file, and the number of days installed for each lamp in the master file. (The number of days installed is calculated from the installation and removal dates for each lamp.) For intersections with more than one main or side street timing, the variables M (first main timing), M1 (second main timing), S (first side street timing) S1 (second side street timing), S2 (third side street timing) were used in the main or side street fields for both timing and master data bases.

TIMING PROGRAM TO COMPUTE TRAFFIC SIGNAL TIMINGS FOR THE FIELDS

"TOTALAVGHR" AND "TOTALAVGCY" USED IN TEST 1 AND TEST 2.

```
SELE B
USE LUXJOE15 INDEX L1 ALIAS LUX
SELE A
USE TIMING INDEX T1 ALIAS TIME
DO WHILE .NOT. EOF()
  STORE CTRLSECNO + MAIN_SIDE + COLOR TO WORKING
  SELE B
  SEEK WORKING
  IF EOF ( ) SET PRINT ON
  ? "NO RECORD FOUND FOR",WORKING
  SET PRINT OFF
  SELE A
  SKIP
  EXIT
ENDIF EOF()
DO WHILE CTRLSECNO + MAIN_SIDE + COLOR = WORKING
  TOTALhours = (TIME->AVGCYCDAY * TIME->AVG_SEC) / 3600
  IF MAIN_SIDE = "M " .OR. MAIN_SIDE = "M1" .AND. COLOR = "G"
    TOTALhour = TOTALhours + 3
  ENDIF MG
IF MAIN_SIDE = "S " .OR. MAIN_SIDE = "S1" .OR. MAIN_SIDE = "S2" _
.AND. COLOR = "R" TOTALhours = TOTALhours + 3
ENDIF SR
  REPLACE TOTALAVGHR WITH TOTALHOURS * (DAYS_IN)
  REPLACE TOTALAVGCY WITH TIME->AVGCYCDAY * (DAYS_IN)
SKIP
ENDDO WHILE CTRLSECNO = WORKING
  SELE A
  SKIP
ENDDO WHILE NOT EOF
RETURN*
```

## FLASHER PROGRAM AND DESCRIPTION

This program calculates the "total on-hours" and "total cycles" that the test lamps experienced during their installation lifetimes in Test 1 flasher installations.

Index files are created and sorts are performed on control section numbers. This is stored in memory. When a match is found, the program then multiplies the value in the "Days In" field by 43,200 (total on-time per day in seconds), divides by 3,600 seconds per hour and places the resulting number in the field "Total Average Hours". The program replaces the field "Total Average Cycles" with 86,400 (total cycles in a 24 hour day) times the value in the "Days Installed" field to get the total average cycles the lamp experienced during the installation period.

Note that the fields "Total Average Hours" and "Total Average Cycles" are used. The numbers that are placed in these fields are not an average but the actual on-time and cycle time that the lamps in the flasher intersections experienced.

TIMING PROGRAM TO COMPUTE FLASHER INSTALLATION TIMINGS FOR THE  
FIELDS "TOTALAVGHR" AND "TOTALAVGCY" USED IN TEST 1

```
SELE B
USE LUXJOE15 INDEX CTRL ALIAS LUX
SELE A
USE FLASH INDEX CTRLF ALIAS FLA
DO WHILE .NOT. EOF()
  STORE CTRLSECNO TO WHERE
  SELE B
  SEEK WHERE
  IF EOF()
    SET PRINT ON
    ? " NO REC FOUND IN LUXJOE15 FOR ", WHERE
    ?
    SET PRINT OFF
  SELE B
  SKIP
  EXIT
ENDIF EOF()
DO WHILE CTRLSECNO = WHERE
  TOTALhours = LUX->DAYS_IN * 43200 / 3600
  REPLACE TOTALAVGHR WITH TOTALHOURS
  REPLACE TOTALAVGCYC WITH 86400 * DAYS_IN
SKIP
ENDDO WHILE CTRLSECNO = WHERE
  SELE A
  SKIP
ENDDO WHILE NOT EOF
RETURN*
```

## SAS PROGRAM AND DESCRIPTION

SAS (Statistical Analysis Software) was used to plot all the figures in Appendix 11. The program shown on the following page plots "Figure 2." This program is similar to all the programs written to plot the figures in Appendix 11.

Program Description - The program classifies all the data in the master dbase file by the fields burnout, lamp type and wattages. The program then sorts the data by total average hours in ascending order. The percentages are then calculated using the base numbers for the different lamp types and the successive number of burned out lamps. The data can then be plotted using a Hewlett Packard 7475A plotter by accumulated percent burnouts and total average hours installed.

SAS PLOTTING PROGRAM FOR FIGURE 2

```
OPTIONS OBS=MAX;
LIBNAME test1 'F:\SAS';
DATA BURN1;
SET test1.SAS;
KEEP LAMP WATTS TOTAVGHR BURNOUT LAMP_TYP DAYS_IN flash_ty;
IF BURNOUT=1 AND FLASH_TY = ' ' ;
IF WATTS > 149 AND LAMP_TYP = 'ST' THEN DO;
    LAMP='STANDARD 12 ' ;          END;
IF WATTS = 135 AND LAMP_TYP = 'KW' THEN DO;
    LAMP='KRYPT W.S. 12' ;        END;
IF ( WATTS > 66 AND WATTS < 70 ) AND LAMP_TYP = 'ST' THEN DO;
    LAMP='STANDARD 8' ;          END;
IF WATTS = 60 AND LAMP_TYP = 'KW' THEN DO;
    LAMP='KRYPT W.S. 8' ;        END;
IF WATTS = 69 AND LAMP_TYP = 'KT' THEN DO;
    LAMP='KRYPT. THERM.' ;       END;
RUN;
PROC SORT DATA=BURN1;
    BY TOTAVGHR LAMP;
RUN;
DATA BURN2;
    SET BURN1;
IF LAMP='STANDARD 12 '          THEN DO; ST12 + 1;
PERCENT = ST12 / 331 * 100; END;
IF LAMP='KRYPT W.S. 12'        THEN DO; KWS12 + 1;
PERCENT = KWS12 /216 * 100; END;
IF LAMP='STANDARD 8'          THEN DO; ST8 + 1;
PERCENT = ST8 /999 * 100; END;
IF LAMP='KRYPT W.S. 8'        THEN DO; KWS8 + 1;
PERCENT = KWS8 /221* 100; END;
IF LAMP='KRYPT. THERM.'       THEN DO; KT +1;
PERCENT = KT /115 * 100; END;
RUN;
GOPTIONS DEVICE=HP7475A;
GOPTIONS ROTATE=PORTRAIT;
GOPTIONS HSIZE=0 VSIZE=0 ;
DATA VATIT;
    LENGTH TEXT $ 28;
FUNCTION='LABEL';X= 5; Y=90;
    XSYS='1'; YSYS='1'; POSITION='3';TEXT='ACCUMULATED';OUTPUT;
    XSYS='1'; YSYS='1'; POSITION='6';TEXT='PERCENT';OUTPUT;
    XSYS='1'; YSYS='1'; POSITION='9';TEXT='BURNOUTS';OUTPUT;
RUN;
AXIS1 LABEL=NONE;
LEGEND1 LABEL= ('LAMP TYPE')
    VALUE=(T=4 'STANDARD 12" LAMPS'
    T=1 'KRYPTON WATT-SAVER 12" LAMPS'
    T=5 'STANDARD 8" LAMPS'
```

```

T-2 'KRYPTON WATT-SAVER 8" LAMPS'
T-3 'KRYPTON THERMISTOR 8" LAMPS');
PROC GPLOT DATA=BURN2;
  LABEL TOTAVGHR= 'TOTAL AVERAGE HOURS INSTALLED';
title1 C-BLUE F-SWISS H-1 'FIGURE 2';
title2 C-RED F-TRIPLEX H-1 'BEST CASE BY LAMP TYPE.';
title3 C-RED F- TRIPLEX H-1 'FOR TOTAL AVERAGE HOURS INSTALLED TEST 1';
  PLOT PERCENT*TOTAVGHR=LAMP /VAXIS=AXIS1
      LEGEND=LEGEND1
      ANNOTATE=VATIT;
SYMBOL1 C-Blue    V-X      I=JOIN;
SYMBOL2 C-RED     V=PLUS   I=JOIN;
SYMBOL3 C-GREEN   V=STAR   I=JOIN;
SYMBOL4 C-BLACK   V=quare  I=JOIN;
SYMBOL5 C-BROWN   V=diamond I=JOIN;
RUN;

```

APPENDIX 8

LAMP DATA FOR TEST 1 AND TEST 2

	PAGE NUMBERS
1. INTRODUCTION .....	8-2
2. TABLE 1: RESULTS SUMMARY TEST 1 .....	8-3
3. TABLE 2: RESULTS SUMMARY TEST 2 .....	8-5
4. LAMP DATA TEST 1 MASTER DBASE FILE .....	8-6
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NOTE: Only the first page of the lamp data files for Test 1 and Test 2 are included in this Appendix.

## INTRODUCTION

Tables 1 and 2 of this Appendix contains the summary results of Test 1 and Test 2 for the lamps from each manufacturer. The complete lamp data master file contains data on 2,040 lamps for Test 1 and 1,440 lamps for Test 2. The Test 1 master file is 45 pages long. The Test 2 master file is 35 pages long. Only the first page of each excerpt from the master file is included in this Appendix.

TABLE 1  
RESULTS SUMMARY TEST 1

LENS SIZE	LAMP MANUFACTURER	VOLTS	WATTS	LAMP TYPE	QUANTITY OF LAMPS INSTALLED	LAMPS NOT INSTALLED	LAMPS NOT RETURNED	KNOCK DOWN	RELAMP	VANDELISM	FLASH. INSTALL	FLASH BURN-OUT	NO FLASH. BURN-OUT	TRAFF BURN-OUT	NO TRAFF BURN-OUT	BASE # USED
12"	Luxor	120	150	Std.	115	5	4	5	4	0	4	4	0	42	56	111
12"	Duro-Test	120	150	Std.	114	6	1	6	8	2	4	2	2	32	62	113
12"	GE	120	165	Std.	115	5	8	7	3	0	6	1	5	14	78	107
12"	Duro-Test	120-125	135	KW	116	4	8	5	1	0	5	1	4	15	82	108
12"	Luxor	120-125	135	KW	112	8	3	1	5	0	7	1	6	27	69	108
8"	Luxor	120	67	Std.	120	0	2	12	7	3	11	6	5	42	47	118
8"	Duro-Test	120	67	Std.	119	1	5	9	3	3	13	8	5	39	52	114
8"	Westinghouse	130	67	Std.-O	117	3	13	8	2	3	0	0	0	15	76	104
8"	Sylvania	130	67	Std.-O	120	0	6	16	14	1	0	0	0	32	51	114
8"	GE	120	67	Std.	120	0	6	15	0	2	11	5	5	35	53	114
8"	Sylvania	130	67	Std.-N	120	0	12	8	12	1	11	0	7	14	67	108
8"	Westinghouse	130	67	Std.-N	119	1	16	15	10	0	11	1	7	25	45	103
8"	GE	120	69	Std.	120	0	6	15	3	0	11	5	4	24	63	114
8"	GE	130	67	Std.	119	1	9	4	14	1	10	3	6	28	54	110
8"	Luxor	120-125	60	KW	118	2	6	9	5	0	11	9	2	32	56	112

8-3





## LAMP DATA TEST 1

## MASTER DBASE FILE

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	SIGNAL KNOCKDOWN	LAMP BURNOUT	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
LS-0001	1709101	LUXOR	ST	4	Y	365	04/01/82	01/19/84	YES	NO	YES	4380	31536000
LS-0002	1709101	LUXOR	ST	4	Y	365	04/01/82	09/09/83	YES	NO	YES	4380	31536000
LS-0003	NOT_INS	LUXOR	ST	0		365	/ /	/ /	YES	NO	NO	0	0
LS-0004	NOT_INS	LUXOR	ST	0		365	/ /	/ /	YES	NO	NO	0	0
LS-0005	NOT_INS	LUXOR	ST	0		365	/ /	/ /	YES	NO	NO	0	0
LS-0006	0807101	LUXOR	ST	4	Y	365	04/01/82	01/16/85	YES	NO	YES	4380	31536000
LS-0007	0501101	LUXOR	ST	7	R	365	04/13/82	03/16/83	YES	NO	YES	2094	284481
LS-0008	0501101	LUXOR	ST	7	Y	365	04/13/82	01/03/85	YES	NO	NO	474	284481
LS-0009	0501101	LUXOR	ST	7	G	365	04/13/82	01/16/85	YES	NO	YES	5097	284481
LS-0010	0313104	LUXOR	ST	2	R	365	04/15/82	01/27/85	YES	NO	NO	1874	306600
LS-0011	0313104	LUXOR	ST	2	Y	365	04/15/82	01/27/85	YES	NO	NO	511	306600
LS-0012	0313104	LUXOR	ST	2	G	365	04/15/82	06/21/83	YES	NO	YES	5280	306600
LS-0013	0313108	LUXOR	ST	8	R	365	04/16/82	01/29/85	YES	NO	NO	1661	306600
LS-0014	0313108	LUXOR	ST	8	Y	365	04/16/82	01/29/85	YES	NO	NO	511	306600
LS-0015	0313108	LUXOR	ST	8	G	365	04/16/82	12/08/83	YES	NO	YES	5493	306600
LS-0016	0309101	LUXOR	ST	2	G	365	04/15/82	06/24/83	YES	NO	YES	3918	306600
LS-0017	0309101	LUXOR	ST	2	Y	365	04/15/82	02/04/85	YES	NO	NO	511	306600
LS-0018	0309101	LUXOR	ST	2	R	365	04/15/82	02/04/85	YES	NO	NO	3236	306600
LS-0019	0309106	LUXOR	ST	6	R	365	04/15/82	07/19/83	YES	NO	YES	1746	306600
LS-0020	0309106	LUXOR	ST	6	Y	365	04/15/82	01/25/85	YES	NO	NO	511	306600
LS-0021	0309106	LUXOR	ST	6	G	365	04/15/82	11/15/83	YES	NO	YES	5408	306600
LS-0022	0408104	LUXOR	ST	5	G	365	04/22/82	08/02/83	YES	NO	YES	4982	306600
LS-0023	0408104	LUXOR	ST	5	Y	365	04/22/82	07/19/84	YES	NO	YES	426	306600
LS-0024	0408104	LUXOR	ST	5	R	365	04/22/82	07/06/84	YES	NO	YES	2257	306600
LS-0025	0313107	LUXOR	ST	10	R	365	04/20/82	04/12/83	YES	NO	YES	6175	306600
LS-0026	0313107	LUXOR	ST	10	Y	365	04/20/82	01/25/85	YES	NO	NO	341	306600
LS-0027	0313107	LUXOR	ST	10	G	365	04/20/82	01/25/85	YES	NO	NO	1150	306600
LS-0028	0313104	LUXOR	ST	10	R	365	04/15/82	05/05/83	YES	NO	YES	5962	306600
LS-0029	0313104	LUXOR	ST	10	Y	365	04/15/82	01/27/85	YES	NO	NO	426	306600
LS-0030	0313104	LUXOR	ST	10	G	365	04/15/82	01/27/85	YES	NO	NO	1278	306600
LS-0031	0517101	LUXOR	ST	2	R	365	04/13/82	01/20/84	YES	NO	NO	2645	482165
LS-0032	0517101	LUXOR	ST	2	Y	365	04/13/82	01/20/84	YES	NO	NO	670	482165
LS-0033	0517101	LUXOR	ST	2	G	365	04/13/82	02/10/83	YES	NO	YES	4353	482165
LS-0034	0408105	LUXOR	ST	7	G	365	04/22/82	09/13/84	YES	NO	YES	4152	229950
LS-0035	0408105	LUXOR	ST	7	Y	365	04/22/82	02/08/85	YES	NO	NO	319	229950
LS-0036	0408105	LUXOR	ST	7	R	365	04/22/82	02/08/85	YES	NO	NO	3194	229950
LS-0037	0501101	LUXOR	ST	11	R	365	04/13/82	03/25/83	YES	NO	YES	5571	284481
LS-0038	0501101	LUXOR	ST	11	Y	365	04/13/82	01/03/85	YES	NO	NO	474	284481
LS-0039	0501101	LUXOR	ST	11	G	365	04/13/82	01/03/85	YES	NO	NO	1620	284481
LS-0040	0313104	LUXOR	ST	6	R	365	04/15/82	01/27/85	YES	NO	NO	1874	306600
LS-0041	0313104	LUXOR	ST	6	Y	365	04/15/82	01/27/85	YES	NO	NO	511	306600
LS-0042	0313104	LUXOR	ST	6	G	365	04/15/82	10/06/83	YES	NO	YES	5280	306600
LS-0043	0313108	LUXOR	ST	3	R	365	04/16/82	01/29/85	YES	NO	NO	1661	306600
LS-0044	0313108	LUXOR	ST	3	Y	365	04/16/82	01/29/85	YES	NO	NO	511	306600
LS-0045	0313108	LUXOR	ST	3	G	365	04/16/82	03/10/83	YES	NO	YES	5493	306600
LS-0046	0415105	LUXOR	ST	5	Y	365	03/30/82	08/31/82	YES	NO	YES	4380	31536000
LS-0047	NOT_INS	LUXOR	ST	0		365	/ /	/ /	YES	NO	NO	0	0
LS-0048	NOT_INS	LUXOR	ST	0		365	/ /	/ /	YES	NO	NO	0	0

## LAMP DATA TEST 2

## MASTER FILE

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
1	0514102	LUXOR	WS	11	R	49	01/28/85	03/18/85	YES	NO	YES	360	30870
2	0514102	LUXOR	WS	11	Y	49	01/28/85	03/18/85	YES	NO	YES	51	30870
3	0514102	LUXOR	WS	11	G	49	01/28/85	03/18/85	YES	NO	YES	679	30870
4	0408104	LUXOR	WS	6	G	382	02/07/85	02/24/86	YES	NO	NO	6360	320880
5	0408104	LUXOR	WS	6	Y	382	02/07/85	02/24/86	YES	NO	NO	446	320880
6	0408104	LUXOR	WS	6	R	382	02/07/85	02/24/86	YES	NO	NO	2362	320880
7	0401105	LUXOR	WS	2	R	403	01/25/85	03/04/86	YES	NO	NO	1410	338520
8	0401105	LUXOR	WS	2	Y	403	01/25/85	03/04/86	YES	NO	NO	564	338520
9	0401105	LUXOR	WS	2	G	403	01/25/85	03/04/86	YES	NO	NO	7697	338520
10	0408101	LUXOR	WS	4	G	384	02/05/85	02/24/86	YES	NO	NO	6438	322560
11	0408101	LUXOR	WS	4	Y	384	02/05/85	02/24/86	YES	NO	NO	448	322560
12	0408101	LUXOR	WS	4	R	384	02/05/85	02/24/86	YES	NO	NO	2330	322560
13	0401106	LUXOR	WS	2	R	402	01/25/85	03/03/86	YES	NO	NO	1407	337680
14	0401106	LUXOR	WS	2	Y	402	01/25/85	03/03/86	YES	NO	NO	563	337680
15	0401106	LUXOR	WS	2	G	402	01/25/85	03/03/86	YES	NO	NO	7678	337680
16	0408101	LUXOR	WS	5	G	384	02/05/85	02/24/86	YES	NO	NO	6438	322560
17	0408101	LUXOR	WS	5	Y	384	02/05/85	02/24/86	YES	NO	NO	448	322560
18	0408101	LUXOR	WS	5	R	384	02/05/85	02/24/86	YES	NO	NO	2330	322560
19	0803106	LUXOR	WS	5	R	404	01/24/85	03/04/86	YES	NO	NO	1768	254520
20	0803106	LUXOR	WS	5	Y	404	01/24/85	03/04/86	YES	NO	NO	354	254520
21	0803106	LUXOR	WS	5	G	404	01/24/85	03/04/86	YES	NO	NO	7575	254520
22	0401106	LUXOR	WS	3	R	402	01/25/85	03/03/86	YES	NO	NO	1407	337680
23	0401106	LUXOR	WS	3	Y	402	01/25/85	03/03/86	YES	NO	NO	563	337680
24	0401106	LUXOR	WS	3	G	402	01/25/85	03/03/86	YES	NO	NO	7678	337680
25	0819101	LUXOR	WS	3	R	365	01/23/85	01/23/86	YES	NO	NO	3089	411866
26	0819101	LUXOR	WS	3	Y	365	01/23/85	01/23/86	YES	NO	NO	572	411866
27	0819101	LUXOR	WS	3	G	365	01/23/85	01/23/86	YES	NO	NO	5099	411866
28	0804101	LUXOR	WS	3	R	352	01/23/85	01/10/86	YES	NO	NO	2587	295680
29	0804101	LUXOR	WS	3	Y	352	01/23/85	01/10/86	YES	NO	NO	411	295680
30	0804101	LUXOR	WS	3	G	352	01/23/85	01/10/86	YES	NO	NO	5450	295680
31	0313107	LUXOR	WS	10	G	398	01/25/85	02/27/86	YES	NO	NO	2448	334320
32	0313107	LUXOR	WS	10	Y	398	01/25/85	02/27/86	YES	NO	NO	1565	334320
33	0313107	LUXOR	WS	10	R	398	01/25/85	02/27/86	YES	NO	NO	7927	334320
34	0313102	LUXOR	WS	5	G	0	01/25/85	/ /	NO	NO	NO	0	0
35	0313102	LUXOR	WS	5	Y	0	01/25/85	/ /	NO	NO	NO	0	0
36	0313102	LUXOR	WS	5	R	0	01/25/85	/ /	NO	NO	NO	0	0
37	0313108	LUXOR	WS	11	G	393	01/29/85	02/26/86	YES	NO	NO	2417	330120
38	0313108	LUXOR	WS	11	Y	393	01/29/85	02/26/86	YES	NO	NO	1546	330120
39	0313108	LUXOR	WS	11	R	393	01/29/85	02/26/86	YES	NO	NO	7827	330120
40	0401107	LUXOR	WS	4	R	401	01/23/85	02/28/86	YES	NO	NO	1404	336840
41	0401107	LUXOR	WS	4	Y	401	01/23/85	02/28/86	YES	NO	NO	561	336840
42	0401107	LUXOR	WS	4	G	401	01/23/85	02/28/86	YES	NO	NO	7659	336840
43	0313107	LUXOR	WS	3	G	398	01/25/85	02/27/86	YES	NO	NO	7184	334320
44	0313107	LUXOR	WS	3	Y	398	01/25/85	02/27/86	YES	NO	NO	557	334320
45	0313107	LUXOR	WS	3	R	398	01/25/85	02/27/86	YES	NO	NO	1811	334320
46	0313105	LUXOR	WS	4	G	89	01/25/85	04/24/85	YES	NO	YES	1544	74760
47	0313105	LUXOR	WS	4	Y	89	01/25/85	04/24/85	YES	NO	YES	125	74760
48	0313105	LUXOR	WS	4	R	89	01/25/85	04/24/85	YES	NO	YES	467	74760

APPENDIX 9

LAMPS NOT RETURNED AT  
END OF TEST 1 AND TEST 2

	PAGE NUMBERS
1. INTRODUCTION .....	9-2
2. LAMPS NOT RETURNED TEST 1 .....	9-3
3. LAMPS NOT RETURNED TEST 2 .....	9-6

## INTRODUCTION

Listed in this Appendix are all the lamps that were not returned from the field at the end of each test. These lamps were not included in the base numbers and are not used in the data reduction process for each test.

Results Summary Tables 1 and 2, in Appendix 8, contains the base numbers and quantity of lamps not returned by lamp manufacturer and lamp type for Test 1 and Test 2.

LAMP DATA TEST 1

LAMPS NOT RETURNED AT END OF TEST 1

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
LS-0059	0313107	LUXOR	ST	9	Y	0	04/20/82	/ /	.F.	0	0	0	0
LS-0061	0313102	LUXOR	ST	2	R	0	04/20/82	/ /	.F.	0	0	0	0
LS-0062	0313102	LUXOR	ST	2	Y	0	04/20/82	/ /	.F.	0	0	0	0
LS-0119	0514101	LUXOR	ST	4	Y	0	04/12/82	/ /	.F.	0	0	0	0
DS-0174	5836105	DURO TEST	ST	7	G	0	04/29/82	/ /	.F.	0	0	0	0
LS-0302	0315101	LUXOR	ST	13	Y	0	04/27/82	/ /	.F.	0	0	0	0
LS-0312	0313103	LUXOR	ST	4	Y	0	04/15/82	/ /	.F.	0	0	0	0
DS-0368	5836101	DURO TEST	ST	4	Y	0	03/30/82	/ /	.F.	0	0	0	0
DS-0412	0315101	DURO TEST	ST	5	G	0	04/27/82	/ /	.F.	0	0	0	0
DS-0439	0408105	DURO TEST	ST	21	G	0	04/22/82	/ /	.F.	0	0	0	0
DS-0440	0408105	DURO TEST	ST	21	Y	0	04/22/82	/ /	.F.	0	0	0	0
DS-0478	0315101	DURO TEST	ST	5	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-0489	0514101	WESTINGHOUSE	ST	16	R	0	04/12/82	/ /	.F.	0	0	0	0
WS-0499	0314101	WESTINGHOUSE	ST	2	R	0	04/23/82	/ /	.F.	0	0	0	0
WS-0500	0314101	WESTINGHOUSE	ST	2	Y	0	04/23/82	/ /	.F.	0	0	0	0
WS-0503	0314101	WESTINGHOUSE	ST	2	G	0	04/23/82	/ /	.F.	0	0	0	0
WS-0515	0315101	WESTINGHOUSE	ST	7	G	0	04/27/82	/ /	.F.	0	0	0	0
WS-0525	0314104	WESTINGHOUSE	ST	4	R	0	04/27/82	/ /	.F.	0	0	0	0
WS-0526	0314104	WESTINGHOUSE	ST	4	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-0557	0314104	WESTINGHOUSE	ST	8	R	0	04/27/82	/ /	.F.	0	0	0	0
WS-0558	0314104	WESTINGHOUSE	ST	8	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-0565	0315101	WESTINGHOUSE	ST	7	R	0	04/27/82	/ /	.F.	0	0	0	0
WS-0566	0315101	WESTINGHOUSE	ST	7	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-0569	0314104	WESTINGHOUSE	ST	4	G	0	04/27/82	/ /	.F.	0	0	0	0
WS-0571	0314104	WESTINGHOUSE	ST	8	G	0	04/27/82	/ /	.F.	0	0	0	0
SS-0652	0313108	SYLVANIA	ST	6	R	0	04/16/82	/ /	.F.	0	0	0	0
SS-0653	0313108	SYLVANIA	ST	6	Y	0	04/16/82	/ /	.F.	0	0	0	0
SS-0654	0313108	SYLVANIA	ST	6	G	0	04/16/82	/ /	.F.	0	0	0	0
SS-0700	0415103	SYLVANIA	ST	4	R	0	04/14/82	/ /	.F.	0	0	0	0
SS-0709	0314104	SYLVANIA	ST	9	R	0	04/27/82	/ /	.F.	0	0	0	0
SS-0710	0314104	SYLVANIA	ST	9	Y	0	04/27/82	/ /	.F.	0	0	0	0
ES-0729	0101110	GENERAL ELEC	ST	2	R	0	03/30/82	/ /	.F.	0	0	0	0
ES-0757	0314103	GENERAL ELEC	ST	8	R	0	04/27/82	/ /	.F.	0	0	0	0
ES-0773	0415102	GENERAL ELEC	ST	6	G	0	04/14/82	/ /	.F.	0	0	0	0
ES-0774	0415102	GENERAL ELEC	ST	6	Y	0	04/14/82	/ /	.F.	0	0	0	0
ES-0808	0315101	GENERAL ELEC	ST	1	R	0	04/27/82	/ /	.F.	0	0	0	0
ES-0809	0315101	GENERAL ELEC	ST	1	Y	0	04/27/82	/ /	.F.	0	0	0	0
SS-0849	0101110	SYLVANIA	ST	4	Y	0	03/30/82	/ /	.F.	0	0	0	0
SS-0853	0313102	SYLVANIA	ST	3	R	0	04/20/82	/ /	.F.	0	0	0	0
SS-0854	0313102	SYLVANIA	ST	3	Y	0	04/20/82	/ /	.F.	0	0	0	0
SS-0855	0313102	SYLVANIA	ST	3	G	0	04/20/82	/ /	.F.	0	0	0	0
SS-0898	0313108	SYLVANIA	ST	2	R	0	04/16/82	/ /	.F.	0	0	0	0
SS-0899	0313108	SYLVANIA	ST	2	Y	0	04/16/82	/ /	.F.	0	0	0	0
SS-0900	0313108	SYLVANIA	ST	2	G	0	04/16/82	/ /	.F.	0	0	0	0
SS-0938	0314101	SYLVANIA	ST	7	Y	0	04/23/82	/ /	.F.	0	0	0	0

LAMP DATA TEST 1

LAMPS NOT RETURNED AT END OF TEST 1

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
SS-0939	0314101	SYLVANIA	ST	7	G	0	04/23/82	/ /	.F.	0	0	0	0
SS-0955	0431101	SYLVANIA	ST	10	R	0	04/14/82	/ /	.F.	0	0	0	0
SS-0956	0431101	SYLVANIA	ST	10	Y	0	04/14/82	/ /	.F.	0	0	0	0
SS-0957	0431101	SYLVANIA	ST	10	G	0	04/14/82	/ /	.F.	0	0	0	0
WS-0969	0101110	WESTINGHOUSE	ST	3	Y	0	03/30/82	/ /	.F.	0	0	0	0
WS-0977	0315101	WESTINGHOUSE	ST	3	R	0	04/27/82	/ /	.F.	0	0	0	0
WS-0978	0315101	WESTINGHOUSE	ST	3	G	0	04/27/82	/ /	.F.	0	0	0	0
WS-0979	0315101	WESTINGHOUSE	ST	3	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-0980	0309104	WESTINGHOUSE	ST	1	Y	0	04/13/82	/ /	.F.	0	0	0	0
WS-0986	0308101	WESTINGHOUSE	ST	4	G	0	04/13/82	/ /	.F.	0	0	0	0
WS-1006	0415103	WESTINGHOUSE	ST	8	Y	0	04/14/82	/ /	.F.	0	0	0	0
WS-1014	0414103	WESTINGHOUSE	ST	3	G	0	04/05/82	/ /	.F.	0	0	0	0
WS-1019	0415102	WESTINGHOUSE	ST	1	G	0	04/14/82	/ /	.F.	0	0	0	0
WS-1020	0314104	WESTINGHOUSE	ST	3	R	0	04/27/82	/ /	.F.	0	0	0	0
WS-1021	0314104	WESTINGHOUSE	ST	3	Y	0	04/27/82	/ /	.F.	0	0	0	0
WS-1022	0314104	WESTINGHOUSE	ST	3	G	0	04/27/82	/ /	.F.	0	0	0	0
WS-1031	0308101	WESTINGHOUSE	ST	8	R	0	04/13/82	/ /	.F.	0	0	0	0
WS-1042	0309103	WESTINGHOUSE	ST	19	Y	0	04/13/82	/ /	.F.	0	0	0	0
WS-1065	0408105	WESTINGHOUSE	ST	13	G	0	04/22/82	/ /	.F.	0	0	0	0
WS-1066	0408105	WESTINGHOUSE	ST	13	Y	0	04/22/82	/ /	.F.	0	0	0	0
ES-1117	0408106	GENERAL ELEC	ST	3	G	0	04/21/82	/ /	.F.	0	0	0	0
ES-1155	0314101	GENERAL ELEC	ST	6	R	0	04/23/82	/ /	.F.	0	0	0	0
ES-1157	0314101	GENERAL ELEC	ST	6	Y	0	04/23/82	/ /	.F.	0	0	0	0
ES-1158	0314101	GENERAL ELEC	ST	6	G	0	04/23/82	/ /	.F.	0	0	0	0
ES-1171	0315101	GENERAL ELEC	ST	9	G	0	04/27/82	/ /	.F.	0	0	0	0
ES-1173	0315101	GENERAL ELEC	ST	9	R	0	04/27/82	/ /	.F.	0	0	0	0
EP-1201	1709101	GENERAL ELEC	ST	3	Y	0	04/01/82	/ /	.F.	0	0	0	0
EP-1233	0313107	GENERAL ELEC	ST	3	G	0	04/20/82	/ /	.F.	0	0	0	0
EP-1263	5836105	GENERAL ELEC	ST	3	G	0	04/29/82	/ /	.F.	0	0	0	0
EP-1276	0408105	GENERAL ELEC	ST	9	G	0	04/22/82	/ /	.F.	0	0	0	0
EP-1312	0504101	GENERAL ELEC	ST	5	R	0	04/12/82	/ /	.F.	0	0	0	0
EP-1313	0504101	GENERAL ELEC	ST	5	Y	0	04/12/82	/ /	.F.	0	0	0	0
EP-1314	0504101	GENERAL ELEC	ST	5	G	0	04/12/82	/ /	.F.	0	0	0	0
EP-1317	0514102	GENERAL ELEC	ST	1	G	0	04/12/82	/ /	.F.	0	0	0	0
LW-1326	1702104	LUXOR	KW	1	R	0	04/01/82	/ /	.F.	0	0	0	0
LW-1401	0315101	LUXOR	KW	10	G	0	04/27/82	/ /	.F.	0	0	0	0
LW-1403	0315101	LUXOR	KW	10	R	0	04/27/82	/ /	.F.	0	0	0	0
LW-1404	0315101	LUXOR	KW	10	Y	0	04/27/82	/ /	.F.	0	0	0	0
LW-1429	0313103	LUXOR	KW	2	R	0	04/15/82	/ /	.F.	0	0	0	0
LW-1430	0313103	LUXOR	KW	2	Y	0	04/15/82	/ /	.F.	0	0	0	0
DW-1446	1702104	DURO TEST	KW	1	R	0	04/01/82	/ /	.F.	0	0	0	0
DW-1455	0431102	DURO TEST	KW	1	R	0	04/08/82	/ /	.F.	0	0	0	0
DW-1458	0313109	DURO TEST	KW	8	G	0	04/16/82	/ /	.F.	0	0	0	0
DW-1464	0413104	DURO TEST	KW	11	G	0	04/01/82	/ /	.F.	0	0	0	0
DW-1553	0314101	DURO TEST	KW	3	Y	0	04/23/82	/ /	.F.	0	0	0	0

LAMP DATA TEST 1

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LAMPS NOT RETURNED AT END OF TEST 1

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LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
DW-1560	0313103	DURO TEST	KW	10	Y	0	04/15/82	/ /	.F.	0	0	0	0
DW-1607	0408105	DURO TEST	KW	5	G	0	04/22/82	/ /	.F.	0	0	0	0
DW-1608	0408105	DURO TEST	KW	5	Y	0	04/22/82	/ /	.F.	0	0	0	0
DW-1609	0408105	DURO TEST	KW	5	R	0	04/22/82	/ /	.F.	0	0	0	0
DW-1618	0313109	DURO TEST	KW	2	G	0	04/16/82	/ /	.F.	0	0	0	0
DW-1658	0514102	DURO TEST	KW	3	G	0	04/12/82	/ /	.F.	0	0	0	0
DW-1660	0504101	DURO TEST	KW	1	R	0	04/12/82	/ /	.F.	0	0	0	0
DW-1662	0504101	DURO TEST	KW	1	Y	0	04/12/82	/ /	.F.	0	0	0	0
DW-1679	0514102	DURO TEST	KW	13	G	0	04/12/82	/ /	.F.	0	0	0	0
LW-1737	0313105	LUXOR	KW	10	G	0	04/16/82	/ /	.F.	0	0	0	0
LW-1754	0408104	LUXOR	KW	13	Y	0	04/22/82	/ /	.F.	0	0	0	0
LW-1796	0408104	LUXOR	KW	3	Y	0	04/29/82	/ /	.F.	0	0	0	0
CK-1844	0413104	CHATHAM ENGR	KT	1	Y	0	04/01/82	/ /	.F.	0	0	0	0
CK-1857	0305104	CHATHAM ENGR	KT	6	G	0	04/21/82	/ /	.F.	0	0	0	0
CK-1888	0415103	CHATHAM ENGR	KT	2	R	0	04/14/82	/ /	.F.	0	0	0	0
CK-1903	0314101	CHATHAM ENGR	KT	10	R	0	04/23/82	/ /	.F.	0	0	0	0
CK-1904	0314101	CHATHAM ENGR	KT	10	Y	0	04/23/82	/ /	.F.	0	0	0	0
ES-1943	0315102	GENERAL ELEC	ST	1	Y	0	04/26/82	/ /	.F.	0	0	0	0
ES-1944	0315102	GENERAL ELEC	ST	1	R	0	04/26/82	/ /	.F.	0	0	0	0
ES-1951	0413106	GENERAL ELEC	ST	4	R	0	03/30/82	/ /	.F.	0	0	0	0
ES-2001	0313109	GENERAL ELEC	ST	9	G	0	04/16/82	/ /	.F.	0	0	0	0
ES-2005	0413109	GENERAL ELEC	ST	8	G	0	04/01/82	/ /	.F.	0	0	0	0
ES-2006	0413109	GENERAL ELEC	ST	8	Y	0	04/01/82	/ /	.F.	0	0	0	0
ES-2024	0431101	GENERAL ELEC	ST	6	Y	0	04/14/82	/ /	.F.	0	0	0	0
ES-2036	0309104	GENERAL ELEC	ST	14	Y	0	04/13/82	/ /	.F.	0	0	0	0
ES-2037	0309104	GENERAL ELEC	ST	14	R	0	04/13/82	/ /	.F.	0	0	0	0

LAMP DATA TEST 2

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LAMPS NOT RETURNED AT END OF TEST 2

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LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
34	0313102	LUXOR	WS	5	G	0	01/25/85	/ /	NO	NO	NO	0	0
35	0313102	LUXOR	WS	5	Y	0	01/25/85	/ /	NO	NO	NO	0	0
36	0313102	LUXOR	WS	5	R	0	01/25/85	/ /	NO	NO	NO	0	0
172	0313102	LUXOR	WS	2	G	0	01/25/85	/ /	NO	NO	NO	0	0
173	0313102	LUXOR	WS	2	Y	0	01/25/85	/ /	NO	NO	NO	0	0
174	0313102	LUXOR	WS	2	R	0	01/25/85	/ /	NO	NO	NO	0	0
175	0426102	LUXOR	WS	1	R	0	01/23/85	/ /	NO	NO	NO	0	0
176	0426102	LUXOR	WS	1	Y	0	01/23/85	/ /	NO	NO	NO	0	0
177	0426102	LUXOR	WS	1	G	0	01/23/85	/ /	NO	NO	NO	0	0
392	0426102	DURO TEST	KW	2	Y	0	01/23/85	/ /	NO	NO	NO	0	0
393	0426102	DURO TEST	KW	2	R	0	01/23/85	/ /	NO	NO	NO	0	0
486	0426102	WESTINGHOUSE	ST	3	G	0	01/23/85	/ /	NO	NO	NO	0	0
497	0426102	WESTINGHOUSE	ST	3	Y	0	01/23/85	/ /	NO	NO	NO	0	0
498	0426102	WESTINGHOUSE	ST	3	R	0	01/23/85	/ /	NO	NO	NO	0	0
508	0426102	WESTINGHOUSE	ST	4	G	0	01/23/85	/ /	NO	NO	NO	0	0
509	0426102	WESTINGHOUSE	ST	4	Y	0	01/23/85	/ /	NO	NO	NO	0	0
510	0426102	WESTINGHOUSE	ST	4	R	0	01/23/85	/ /	NO	NO	NO	0	0
1192	0426112	WESTINGHOUSE	ST	3	G	0	02/15/85	/ /	NO	NO	NO	0	0
1309	0313102	WESTINGHOUSE	ST	10	G	0	01/25/85	/ /	NO	NO	NO	0	0
1310	0313102	WESTINGHOUSE	ST	10	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1311	0313102	WESTINGHOUSE	ST	10	R	0	01/25/85	/ /	NO	NO	NO	0	0
1312	0313102	WESTINGHOUSE	ST	12	G	0	01/25/85	/ /	NO	NO	NO	0	0
1313	0313102	WESTINGHOUSE	ST	12	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1314	0313102	WESTINGHOUSE	ST	12	R	0	01/25/85	/ /	NO	NO	NO	0	0
1321	0313102	WESTINGHOUSE	ST	13	G	0	01/25/85	/ /	NO	NO	NO	0	0
1322	0313102	WESTINGHOUSE	ST	13	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1323	0313102	WESTINGHOUSE	ST	13	R	0	01/25/85	/ /	NO	NO	NO	0	0
1324	0313102	WESTINGHOUSE	ST	6	G	0	01/25/85	/ /	NO	NO	NO	0	0
1325	0313102	WESTINGHOUSE	ST	6	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1326	0313102	WESTINGHOUSE	ST	6	R	0	01/25/85	/ /	NO	NO	NO	0	0
1327	0313102	WESTINGHOUSE	ST	3	G	0	01/25/85	/ /	NO	NO	NO	0	0
1328	0313102	WESTINGHOUSE	ST	3	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1329	0313102	WESTINGHOUSE	ST	3	R	0	01/25/85	/ /	NO	NO	NO	0	0
1330	0313102	WESTINGHOUSE	ST	7	G	0	01/25/85	/ /	NO	NO	NO	0	0
1331	0313102	WESTINGHOUSE	ST	7	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1332	0313102	WESTINGHOUSE	ST	7	R	0	01/25/85	/ /	NO	NO	NO	0	0
1336	0313102	WESTINGHOUSE	ST	8	G	0	01/25/85	/ /	NO	NO	NO	0	0
1337	0313102	WESTINGHOUSE	ST	8	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1338	0313102	WESTINGHOUSE	ST	8	R	0	01/25/85	/ /	NO	NO	NO	0	0
1345	0313102	WESTINGHOUSE	ST	11	G	0	01/25/85	/ /	NO	NO	NO	0	0
1346	0313102	WESTINGHOUSE	ST	11	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1347	0313102	WESTINGHOUSE	ST	11	R	0	01/25/85	/ /	NO	NO	NO	0	0
1348	0313102	WESTINGHOUSE	ST	9	G	0	01/25/85	/ /	NO	NO	NO	0	0
1349	0313102	WESTINGHOUSE	ST	9	Y	0	01/25/85	/ /	NO	NO	NO	0	0
1350	0313102	WESTINGHOUSE	ST	9	R	0	01/25/85	/ /	NO	NO	NO	0	0

APPENDIX 10

CHATHAM ENGINEERING LAMPS

	PAGE NUMBERS
1. INTRODUCTION .....	10-2
2. FIGURES A, B, C .....	10-5
3. INSPECTION DATA: TABLE 1 AND TABLE 2 .....	10-6
4. LAMP DATA TEST 1 RESULTS CHATHAM ENGINEERING "GARD LAMPS" .....	10-10

## INTRODUCTION

At the request of Sussex County the New Jersey Department of Transportation assumed maintenance responsibilities for the traffic signals located at the intersection of Sussex County Route 616 and Diller Avenue. The signals had been placed in operation in November 1981 with Chatham Engineering "Gard Lamps" installed. These lamps are referred to as krypton thermistor in this report.

Electrical bureau maintenance personnel had to make five emergency calls to replace burned-out lamps and change three lamp sockets damaged by the lamps. In each instance of a damaged socket the thermistor at the base of the lamp had deteriorated. Broken pieces of thermistor apparently shorted the lamp socket causing arcing which damaged the socket. Due to the problems with these lamps the Electrical bureau personnel removed all of the "Gard Lamps" from this traffic signal installation.

All burned-out "Gard Lamps" from Test 1 were then inspected under 3X and 30X magnification. Tables 1 and 2 contain the results of the inspections. Most of the thermistors at the base of the lamps were cracked.

Apparently there was a production problem with the placement of the thermistor on the base of the lamp and perhaps even with the thermistor material.

Indications are that the bond between the thermistor material and the solder is stronger than that bond between the thermistor material and itself.

Where the thermistor was wetted by the solder and pieces of the thermistor came off, thermistor material remained with the solder on the base of the lamp. Also there is a wide variation in the amount of solder wetting of the thermistor material.

The thermistors on the bases of the lamps were broken into pieces, although still attached to the lamps. The pressure from the central contact in the traffic signal lamp socket combined with the brittleness of the thermistor, the misalignment of the thermistor parallel to the plane of the base of the lamp and solder voids under the thermistor causes the thermistor material to break into pieces. Depending on the socket design the pieces can short-out the lamp.

See Figures A, B, C for a conceptualization of the socket failure mode. Arcing and burning of the socket and the lamp base takes place until thermistor pieces shorting the lamp is removed by melting of the socket, melting or vaporizing the contacts or a combination. Unlike the Sussex County lamps, none of the "Gard Lamp" failures in Test 1 have caused lamp sockets to short-out.

During the 30X inspection visual evidence points to the cracking of the thermistor during manufacturing. This cracking can be either vertical or parallel to the surface of the thermistor. Not all cracking parallel to the thermistor surface can be detected visually after manufacturing. It can be determined by the ease with which the thermistor can be lifted off of the base of the lamp with a knife blade and viewing thermistor material still attached to the solder.

An additional effect was discovered during the 30X inspection.

See Table 2, comments for lamp item numbers 5 and 17. Probably at burnout, the higher than normal current carried through the thermistor causes a burn-melt area the diameter of which is estimated to be twice the diameter of the power lead. Cracking can radiate from the burn-melt hole in the thermistor.

The seventeen lamps evaluated represent 14.2 percent of the "Gard Lamps" in Test 1 which is designed to determine the installed field lifetimes of the various types of traffic signal lamps through actual use. The problems outlined above contributed to the "Gard Lamp" failures. Chatham Engineering had claimed a 16,500 hour lifetime for "Gard Lamps."

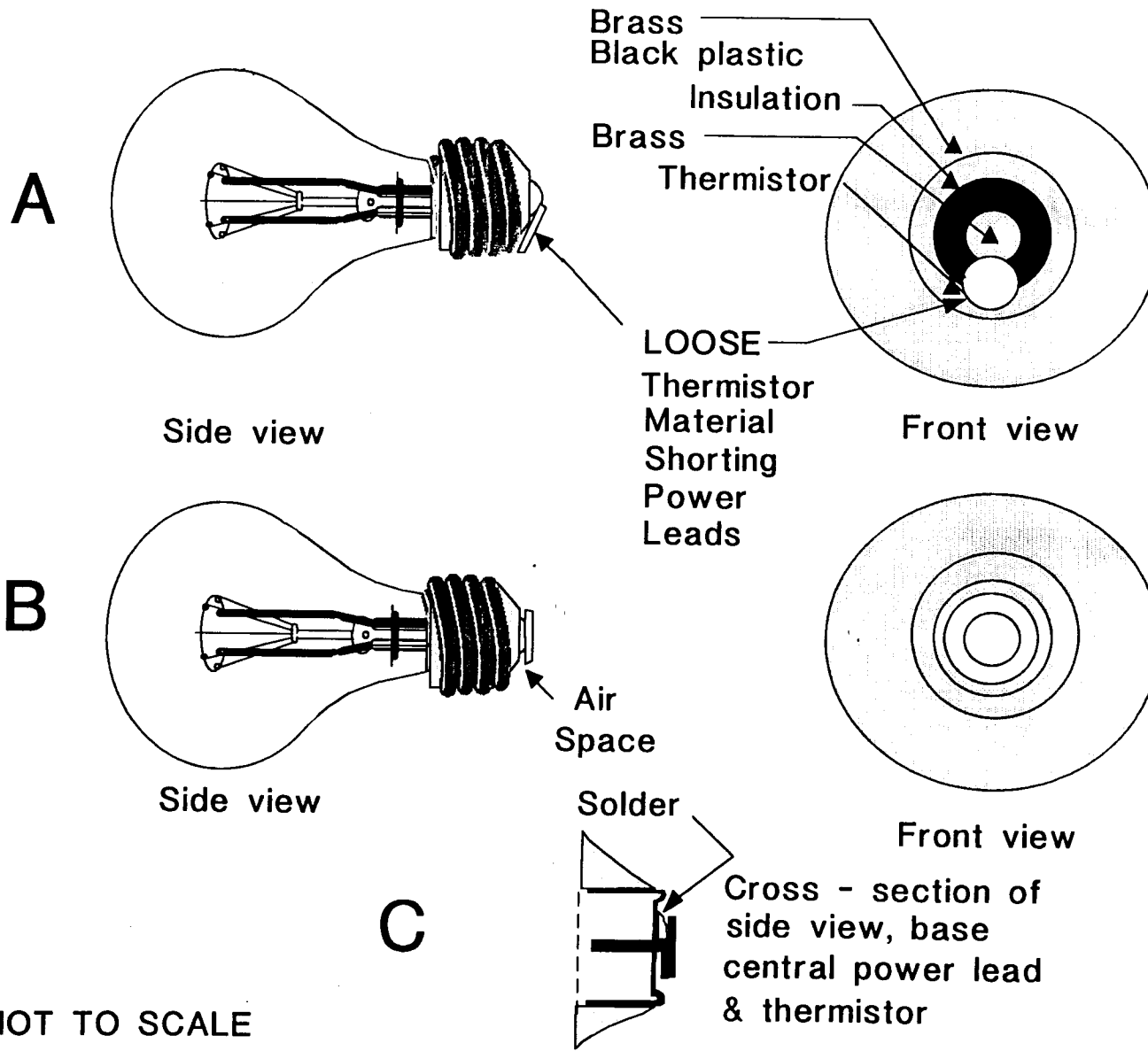


TABLE 1 - 3X MAGNIFICATION INSPECTION

ALL FILAMENTS HAVE BURNED OUT

<u>Item Number</u>	<u>NJDOT # Scribed on Base of Lamp</u>	<u>Traffic or Flasher</u>	<u>Color</u>	<u>Date In</u>	<u>Date Out</u>	<u>Remarks</u>
1.	1806	F	Y	4/1/82	1/4/83	Thermistor removed during inspection, only bonded to solder at 3 points approximately 1/5 of the area of the thermistor.
2.	1813	T	G	3/30/82	11/4/82	Thermistor cracked.
3.	1830	T	G	4/27/82	10/12/82	Thermistor cracked.
4.	1834	T	R	4/14/82	1/26/83	Thermistor cracked, 1/3 not bonded.
5.	1840	T	G	4/29/82	8/9/82	Thermistor cracked.
6.	1846	T	G	4/26/82	5/10/82	Thermistor missing.
7.	1847*	T	Y	4/26/82	1/30/83	85% of the thermistor missing.
8.	1848*	T	R	4/26/82	1/30/83	95% of the thermistor missing.
9.	1855	T	R	4/21/82	10/21/82	Thermistor cracked? 1/2 not bonded.
10.	1860	T	R	4/1/82	10/12/82	2/3 thermistor missing.
11.	1869*	T	G	4/14/82	10/13/82	Thermistor cracked & lifted off.
12.	1877	T	G	4/13/82	12/22/82	95% thermistor missing.
13.	1882	T	G	4/12/82	1/27/83	Thermistor cracked.
14.	1885	T	G	3/30/82	11/5/82	Thermistor cracked?
15.	1890	T	G	4/14/82	11/30/82	Thermistor cracked small piece missing, 1/3 to 1/2 not bonded.

\*only base returned

16.	1896	T	R	4/16/82	9/3/82	Thermistor cracked, piece missing.
17.	1902	T	R	4/12/82	11/30/82	1/2 thermistor missing.
18.	1918	T	G	4/13/82	9/18/82	Knocked down, not returned.
19.	1919	T	Y	4/13/82	9/18/82	Knocked down, not returned.
20.	1920	T	R	4/13/82	9/18/82	Knocked down, not returned.

TABLE 2 - 30X MAGNIFICATION INSPECTION

<u>Item Number</u>	<u>Lamp Number</u>	<u>Description</u>
1.	1806	Thermistor removed during inspection by a knife blade. No heat applied. Thermistor was only bonded to the solder at three points. Bond area is equivalent to approximately 1/5 of the area of the thermistor.
2.	1813	Thermistor cracked. Ridge of solder along one edge of the thermistor suggests that the thermistor was installed at an angle to the plane of the base of the lamp during manufacturing (during thermistor placement).
3.	1830	Thermistor cracked on one side. The side opposite the crack is bonded to the lamp base. The thermistor is at an angle to the plane of the base. See Figure B.
4.	1834	Surface cracking not evident. Voids under thermistor are visible. Thermistor is at an angle to the plane of the base. Solder did not wet the sides of the thermistor.
5.	1840	Thermistor cracked. Cracks radiate from burn-melt hole which was probed with a knife blade. Burn-melt hole probably occurred during the burnout of the filament.
6.	1846	Internal reflector fell off. 95% of the thermistor is missing.
7.	1847	Only base returned. 85% of the thermistor is missing. Only a chip remains.
8.	1848	Only base returned. 95% of the thermistor is missing.
9.	1855	Hairline fracture from top to bottom at one edge of the thermistor. 1/2 to 2/3 of the thermistor not bonded. Thermistor is at an angle to the plane of the base of the lamp.
10.	1860	2/3 of the thermistor is missing. Solder on the vertical faces of the remaining thermistor material suggests that the thermistor was cracked during installation of the thermistor on the base of the bulb during manufacturing.
11.	1869	Only base returned. The thermistor cracked and lifted off. The thermistor was installed at an angle to the plane of the base. The

thermistor was resting on the central power lead and could not be pushed further into the base. See Figure C.

12. 1877 Thermistor cracked. 95% of the thermistor is missing.
13. 1882 Internal reflector fell off. Thermistor cracked into two pieces. The largest piece is at an angle to the plane of the base. Voids exist under the small part of the thermistor. Smaller pieces are at an angle to the plane of the base. One suggestion is that the cracking was caused during manufacturing.
14. 1885 No noticeable thermistor cracks.
15. 1890 Thermistor cracked into four pieces, three small and one large. One small piece is missing. One half of thermistor is not bonded. The large piece is at an angle to the plane of the base.
16. 1896 Thermistor cracked into four pieces. One "pie slice" shaped piece is missing. The solderline up the two exposed sides where the missing piece fell off indicates that the thermistor was cracked during manufacturing.
17. 1902 Thermistor cracked into four "pie slice" shaped pieces. Two opposing pieces are missing. One piece has indications of burn-melt through along one edge. Diameter of the burn-melt through area is approximately twice the diameter of the power lead. Four solder ridges outline the four pieces. Indications point to the cracking of the thermistor into four pieces during the installation of the thermistor on the base of the lamp and the solder moving up into the cracks before solidifying.

LAMP DATA TEST 1 RESULTS  
 CHATHAM ENGINEERING "GARD LAMPS"

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
CK-1801	5836104	CHATHAM	ENGR KT	3	Y	1070	03/30/82	03/04/85	.T.	0	0	12840	92448000
CK-1802	0106103	CHATHAM	ENGR KT	2	R	553	03/30/82	10/04/83	.T.	1	0	6636	47779200
CK-1803	0510101	CHATHAM	ENGR KT	4	Y	1078	03/30/82	03/12/85	.T.	0	0	12936	93139200
CK-1804	1703105	CHATHAM	ENGR KT	1	R	835	03/30/82	07/12/84	.T.	1	0	10020	72144000
CK-1805	0608102	CHATHAM	ENGR KT	1	R	1068	04/01/82	03/04/85	.T.	0	0	12816	92275200
CK-1806	1702104	CHATHAM	ENGR KT	3	Y	278	04/01/82	01/04/83	.T.	1	0	3336	24019200
CK-1807	5836101	CHATHAM	ENGR KT	2	R	764	03/30/82	05/02/84	.T.	0	0	9168	66009600
CK-1808	1703102	CHATHAM	ENGR KT	2	Y	1079	03/31/82	03/14/85	.T.	0	0	12948	93225600
CK-1809	0604101	CHATHAM	ENGR KT	2	R	963	04/01/82	11/19/84	.T.	1	0	11556	83203200
CK-1810	0604107	CHATHAM	ENGR KT	3	Y	1034	04/01/82	01/29/85	.T.	0	0	12408	89337600
CK-1811	0305101	CHATHAM	ENGR KT	10	G	918	04/29/82	11/02/84	.T.	1	0	11567	771120
CK-1812	0305101	CHATHAM	ENGR KT	10	G	1023	04/29/82	02/15/85	.T.	0	0	12890	859320
CK-1813	0413106	CHATHAM	ENGR KT	3	G	219	03/30/82	11/04/82	.T.	1	0	3564	137970
CK-1814	0413106	CHATHAM	ENGR KT	3	Y	1074	03/30/82	03/08/85	.T.	0	0	940	676620
CK-1815	0413106	CHATHAM	ENGR KT	3	R	1074	03/30/82	03/08/85	.T.	0	0	4135	676620
CK-1816	0313105	CHATHAM	ENGR KT	14	R	299	04/16/82	02/09/83	.T.	1	0	4849	251160
CK-1817	0313105	CHATHAM	ENGR KT	14	Y	1015	04/16/82	01/25/85	.T.	0	0	1184	852600
CK-1818	0313105	CHATHAM	ENGR KT	14	G	1015	04/16/82	01/25/85	.T.	0	0	3671	852600
CK-1819	0413109	CHATHAM	ENGR KT	4	G	428	04/01/82	06/03/83	.T.	1	0	4344	359520
CK-1820	0413109	CHATHAM	ENGR KT	4	Y	1070	04/01/82	03/06/85	.T.	0	0	1248	898800
CK-1821	0413109	CHATHAM	ENGR KT	4	R	1070	04/01/82	03/06/85	.T.	0	0	10361	898800
CK-1822	0431102	CHATHAM	ENGR KT	3	G	394	04/08/82	05/07/83	.T.	1	0	6426	419531
CK-1823	0431102	CHATHAM	ENGR KT	2	Y	629	04/08/82	12/28/83	.T.	0	0	930	669759
CK-1824	0431102	CHATHAM	ENGR KT	2	R	629	04/08/82	12/28/83	.T.	0	0	3907	669759
CK-1825	0413108	CHATHAM	ENGR KT	6	G	369	03/30/82	04/03/83	.T.	1	0	6101	236160
CK-1826	0413108	CHATHAM	ENGR KT	6	Y	1041	03/30/82	02/03/85	.T.	0	0	925	666240
CK-1827	0413108	CHATHAM	ENGR KT	6	R	1074	03/30/82	03/08/85	.T.	0	0	4201	687360
CK-1828	0314103	CHATHAM	ENGR KT	9	R	1014	04/27/82	02/04/85	.T.	0	0	5797	851760
CK-1829	0314103	CHATHAM	ENGR KT	9	Y	1014	04/27/82	02/04/85	.T.	0	0	1183	851760
CK-1830	0314103	CHATHAM	ENGR KT	9	G	168	04/27/82	10/12/82	.T.	1	0	2372	141120
CK-1831	0304104	CHATHAM	ENGR KT	6	G	750	04/20/82	05/09/84	.T.	1	0	9625	630000
CK-1832	0304104	CHATHAM	ENGR KT	6	Y	1028	04/20/82	02/11/85	.T.	0	0	1199	863520
CK-1833	0304104	CHATHAM	ENGR KT	6	R	1028	04/20/82	02/11/85	.T.	0	0	7196	863520
CK-1834	0415102	CHATHAM	ENGR KT	11	R	287	04/14/82	01/26/83	.T.	1	0	4293	297217
CK-1835	0415102	CHATHAM	ENGR KT	11	Y	1057	04/14/82	03/06/85	.T.	0	0	912	1094629
CK-1836	0415102	CHATHAM	ENGR KT	11	G	1057	04/14/82	03/06/85	.T.	0	0	5473	1094629
CK-1837	0305108	CHATHAM	ENGR KT	1	R	1015	04/21/82	01/30/85	.T.	0	0	5874	1208358
CK-1838	0305108	CHATHAM	ENGR KT	1	Y	1015	04/21/82	01/30/85	.T.	0	0	2014	1208358
CK-1839	0305108	CHATHAM	ENGR KT	1	G	695	04/21/82	03/16/84	.T.	1	0	9193	827398
CK-1840	0416102	CHATHAM	ENGR KT	4	G	102	04/29/82	08/09/82	.T.	1	0	1499	85680
CK-1841	0416102	CHATHAM	ENGR KT	4	Y	1012	04/29/82	02/04/85	.T.	0	0	1181	850080
CK-1842	0416102	CHATHAM	ENGR KT	4	R	636	04/29/82	01/25/84	.T.	1	0	3265	534240
CK-1843	0413104	CHATHAM	ENGR KT	1	G	791	04/01/82	05/31/84	.T.	1	0	10889	664440
CK-1844	0413104	CHATHAM	ENGR KT	1	Y	0	04/01/82	/ /	.F.	0	0	0	0
CK-1845	0413104	CHATHAM	ENGR KT	1	R	951	04/01/82	11/07/84	.T.	1	0	5769	798840
CK-1846	0416101	CHATHAM	ENGR KT	4	G	14	04/26/82	05/10/82	.T.	1	0	206	11760
CK-1847	0416101	CHATHAM	ENGR KT	4	Y	279	04/26/82	01/30/83	.T.	0	1	326	234360

LAMP DATA TEST 1 RESULTS  
CHATHAM ENGINEERING "GARD LAMPS"

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
CK-1848	0416101	CHATHAM ENGR	KT	4	R	279	04/26/82	01/30/83	.T.	0	1	1432	234360
CK-1849	0309101	CHATHAM ENGR	KT	14	G	748	04/15/82	05/02/84	.T.	1	0	5236	628320
CK-1850	0309101	CHATHAM ENGR	KT	14	Y	1026	04/15/82	02/04/85	.T.	0	0	958	861840
CK-1851	0309101	CHATHAM ENGR	KT	14	R	349	04/15/82	03/30/83	.T.	1	0	4560	293160
CK-1852	0314102	CHATHAM ENGR	KT	2	R	475	04/23/82	08/11/83	.T.	0	1	2549	399000
CK-1853	0314102	CHATHAM ENGR	KT	2	Y	475	04/23/82	08/11/83	.T.	0	1	554	399000
CK-1854	0314102	CHATHAM ENGR	KT	2	G	296	04/23/82	02/13/83	.T.	1	0	4282	248640
CK-1855	0305104	CHATHAM ENGR	KT	6	R	183	04/21/82	10/21/82	.T.	1	0	2904	153720
CK-1856	0305104	CHATHAM ENGR	KT	6	Y	1015	04/21/82	01/30/85	.T.	0	0	710	852600
CK-1857	0305104	CHATHAM ENGR	KT	6	G	0	04/21/82	. / /	.F.	0	0	0	0
CK-1858	0413102	CHATHAM ENGR	KT	12	G	1072	04/01/82	03/08/85	.T.	0	0	2533	675360
CK-1859	0413102	CHATHAM ENGR	KT	12	Y	1072	04/01/82	03/08/85	.T.	0	0	563	675360
CK-1860	0413102	CHATHAM ENGR	KT	12	R	194	04/01/82	10/12/82	.T.	1	0	3514	122220
CK-1861	0415104	CHATHAM ENGR	KT	9	R	468	04/15/82	07/27/83	.T.	1	0	7713	447876
CK-1862	0415104	CHATHAM ENGR	KT	9	Y	785	04/15/82	06/08/84	.T.	0	1	626	751245
CK-1863	0415104	CHATHAM ENGR	KT	9	G	785	04/15/82	06/08/84	.T.	0	1	2922	751245
CK-1864	0309106	CHATHAM ENGR	KT	11	G	1016	04/15/82	01/25/85	.T.	0	0	3675	853440
CK-1865	0309106	CHATHAM ENGR	KT	11	Y	1016	04/15/82	01/25/85	.T.	0	0	7586	853440
CK-1866	0309106	CHATHAM ENGR	KT	11	R	518	04/15/82	09/15/83	.T.	1	0	8642	435120
CK-1867	0431101	CHATHAM ENGR	KT	4	R	1044	04/14/82	02/21/85	.T.	0	0	5951	1127520
CK-1868	0431101	CHATHAM ENGR	KT	4	Y	734	04/14/82	04/17/84	.T.	1	0	1321	792720
CK-1869	0431101	CHATHAM ENGR	KT	4	G	182	04/14/82	10/13/82	.T.	0	0	2457	196560
CK-1870	0414101	CHATHAM ENGR	KT	2	G	386	04/05/82	04/26/83	.T.	1	0	4236	265182
CK-1871	0414101	CHATHAM ENGR	KT	2	Y	1069	04/05/82	03/09/85	.T.	0	0	1224	734403
CK-1872	0414101	CHATHAM ENGR	KT	2	R	1069	04/05/82	03/09/85	.T.	0	0	9486	734403
CK-1873	0309102	CHATHAM ENGR	KT	8	G	1059	04/19/82	03/13/85	.T.	0	0	5360	964749
CK-1874	0309102	CHATHAM ENGR	KT	8	Y	1059	04/19/82	03/13/85	.T.	0	0	1072	964749
CK-1875	0309102	CHATHAM ENGR	KT	8	R	502	04/19/82	09/03/83	.T.	1	0	7495	457322
CK-1876	0309104	CHATHAM ENGR	KT	5	Y	1027	04/13/82	02/03/85	.T.	0	0	1438	862680
CK-1877	0309104	CHATHAM ENGR	KT	5	G	253	04/13/82	12/22/82	.T.	1	0	2893	212520
CK-1878	0309104	CHATHAM ENGR	KT	5	R	1027	04/13/82	02/03/85	.T.	0	0	8387	862680
CK-1879	0415103	CHATHAM ENGR	KT	11	R	397	04/14/82	05/16/83	.T.	1	0	6322	329828
CK-1880	0415103	CHATHAM ENGR	KT	11	Y	1065	04/14/82	03/14/85	.T.	0	0	1229	884802
CK-1881	0415103	CHATHAM ENGR	KT	11	G	1065	04/14/82	03/14/85	.T.	0	0	4178	884802
CK-1882	0414104	CHATHAM ENGR	KT	4	G	290	04/12/82	01/27/83	.T.	1	0	4195	243600
CK-1883	0414104	CHATHAM ENGR	KT	4	Y	1062	04/12/82	03/09/85	.T.	0	0	1487	892080
CK-1884	0414104	CHATHAM ENGR	KT	4	R	1062	04/12/82	03/09/85	.T.	0	0	5452	892080
CK-1885	0413108	CHATHAM ENGR	KT	3	G	220	03/30/82	11/05/82	.T.	1	0	3637	140800
CK-1886	0413108	CHATHAM ENGR	KT	3	Y	1074	03/30/82	03/08/85	.T.	0	0	955	687360
CK-1887	0413108	CHATHAM ENGR	KT	3	R	1074	03/30/82	03/08/85	.T.	0	0	4201	687360
CK-1888	0415103	CHATHAM ENGR	KT	2	R	0	04/14/82	/ /	.F.	0	0	0	0
CK-1889	0415103	CHATHAM ENGR	KT	2	Y	1065	04/14/82	03/14/85	.T.	0	0	1229	884802
CK-1890	0415103	CHATHAM ENGR	KT	2	G	230	04/14/82	11/30/82	.T.	1	0	2389	191084
CK-1891	0414103	CHATHAM ENGR	KT	6	G	343	04/05/82	03/14/83	.T.	1	0	5162	288120
CK-1892	0414103	CHATHAM ENGR	KT	6	Y	1025	04/05/82	01/24/85	.T.	0	0	1196	861000
CK-1893	0414103	CHATHAM ENGR	KT	6	R	1025	04/05/82	01/24/85	.T.	0	0	4903	861000
CK-1894	0309107	CHATHAM ENGR	KT	12	G	1000	04/16/82	01/10/85	.T.	0	0	3617	840000

LAMP DATA TEST 1 RESULTS  
CHATHAM ENGINEERING "GARD LAMPS"

LAMP NUMBER	CONTROL SECTION	LAMP MANUFACTURER	LAMP TYPE	HEAD NUMBER	LENS COLOR	DAYS INSTALLED	INSTALLATION DATE	REMOVAL DATE	LAMP RETURNED	LAMP BURNOUT	SIGNAL KNOCKDOWN	TOTAL AVERAGE HOURS	TOTAL AVERAGE CYCLES
CK-1895	0309107	CHATHAM	ENGR KT	12	Y	1000	04/16/82	01/10/85	.T.	0	0	700	840000
CK-1896	0309107	CHATHAM	ENGR KT	12	R	140	04/16/82	09/03/82	.T.	1	0	2336	117600
CK-1897	0315101	CHATHAM	ENGR KT	8	R	330	04/27/82	03/23/83	.T.	0	0	5390	277200
CK-1898	0315101	CHATHAM	ENGR KT	8	Y	1014	04/27/82	02/04/85	.T.	0	0	710	851760
CK-1899	0315101	CHATHAM	ENGR KT	8	G	330	04/27/82	03/23/83	.T.	0	0	1309	277200
CK-1900	0504101	CHATHAM	ENGR KT	8	G	988	04/12/82	12/25/84	.T.	0	0	5572	1114464
CK-1901	0504101	CHATHAM	ENGR KT	8	Y	988	04/12/82	12/25/84	.T.	0	0	1238	1114464
CK-1902	0504101	CHATHAM	ENGR KT	8	R	232	04/12/82	11/30/82	.T.	1	0	3271	261696
CK-1903	0314101	CHATHAM	ENGR KT	10	R	0	04/23/82	/ /	.F.	0	0	0	0
CK-1904	0314101	CHATHAM	ENGR KT	10	Y	0	04/23/82	/ /	.F.	0	0	0	0
CK-1905	0314101	CHATHAM	ENGR KT	10	G	504	04/23/82	09/09/83	.T.	1	0	6938	423360
CK-1906	0408106	CHATHAM	ENGR KT	6	G	427	04/21/82	06/22/83	.T.	1	0	5829	358680
CK-1907	0408106	CHATHAM	ENGR KT	6	Y	1023	04/21/82	02/07/85	.T.	0	0	1194	859320
CK-1908	0408106	CHATHAM	ENGR KT	6	R	1023	04/21/82	02/07/85	.T.	0	0	6326	859320
CK-1909	0304103	CHATHAM	ENGR KT	2	G	495	04/20/82	08/28/83	.T.	1	0	5428	415800
CK-1910	0304103	CHATHAM	ENGR KT	2	Y	1022	04/20/82	02/05/85	.T.	0	0	1192	858480
CK-1911	0304103	CHATHAM	ENGR KT	2	R	1022	04/20/82	02/05/85	.T.	0	0	9062	858480
CK-1912	0313107	CHATHAM	ENGR KT	2	R	1011	04/20/82	01/25/85	.T.	0	0	4600	849240
CK-1913	0313107	CHATHAM	ENGR KT	2	Y	1011	04/20/82	01/25/85	.T.	0	0	1415	849240
CK-1914	0313107	CHATHAM	ENGR KT	2	G	534	04/20/82	10/06/83	.T.	1	0	8037	448560
CK-1915	0408103	CHATHAM	ENGR KT	2	G	336	04/22/82	03/24/83	.T.	1	0	4743	282240
CK-1916	0408103	CHATHAM	ENGR KT	2	Y	1022	04/22/82	02/07/85	.T.	0	0	1192	858480
CK-1917	0408103	CHATHAM	ENGR KT	2	R	1022	04/22/82	02/07/85	.T.	0	0	5842	858480
CK-1918	0308102	CHATHAM	ENGR KT	1	G	158	04/13/82	09/18/82	.T.	0	1	2267	132720
CK-1919	0308102	CHATHAM	ENGR KT	1	Y	158	04/13/82	09/18/82	.T.	0	1	221	132720
CK-1920	0308102	CHATHAM	ENGR KT	1	R	158	04/13/82	09/18/82	.T.	0	1	830	132720

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## INTRODUCTION

Traffic signal lamp data was plotted using SAS, a statistical analysis software package, on an IBM PS-2 Model-80 microcomputer and a Hewlett-Packard 7475A plotter. The ordinate for all graphs, except the ones in Figures 29 and 30, are labeled, "Accumulated Percent Burnouts." The abscissa for all the graphs, except for the ones in Figures 29 and 30, are labeled either "Days Installed," "Total Average On-Hours Installed," or "Total Average Cycles."

In determining the accumulated percent burnouts only lamps that were installed, burned out and were returned at the end of the test were included in the calculations. This is the best case. Best case does not include lamps not installed, lamps not returned, lamps knocked down, lamps replaced because of accidental relamping or vandalized lamps. Worst case assumes that lamps knocked down, lamps removed because of accidental relamping and vandalized lamps burned out on the date of their removal.

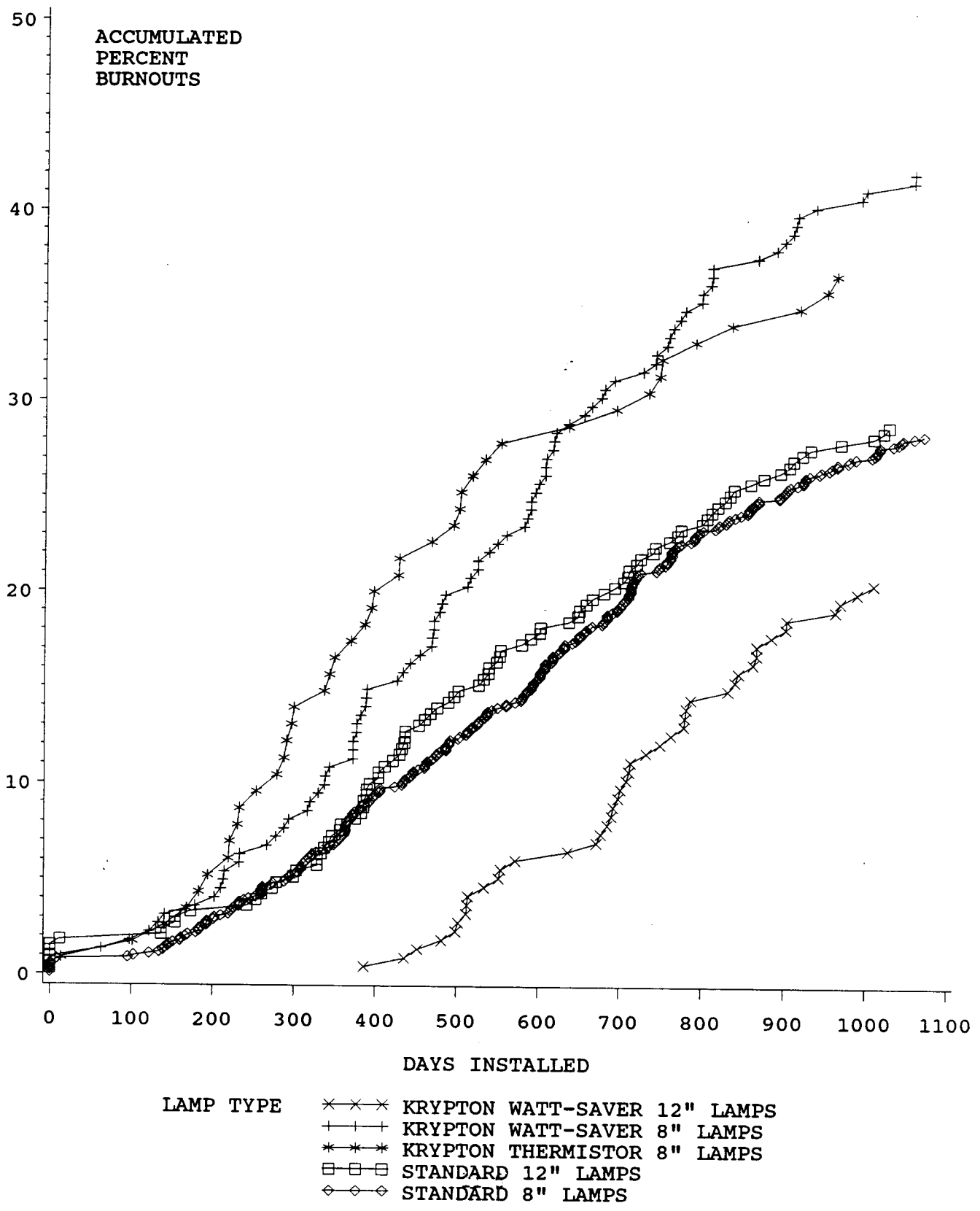
The Chart on Page 11-5 further characterizes the graphs contained in each figure.

The accumulated percent burnouts per lamp type closest to 6,000 and 8,000 "Total Average On-Hours Installed" in the data base was used to determine the call-out replacement cost per 1,000 lamps at \$50 minimum per call-out. To this cost was added the variable lamp cost from \$.20 to \$5.00 per lamp in quantities of 1,000 lamps. This ownership cost per 1,000 lamps per lamp type is contained in Tables 1 and 2, and is plotted in Figures 29 and 30.

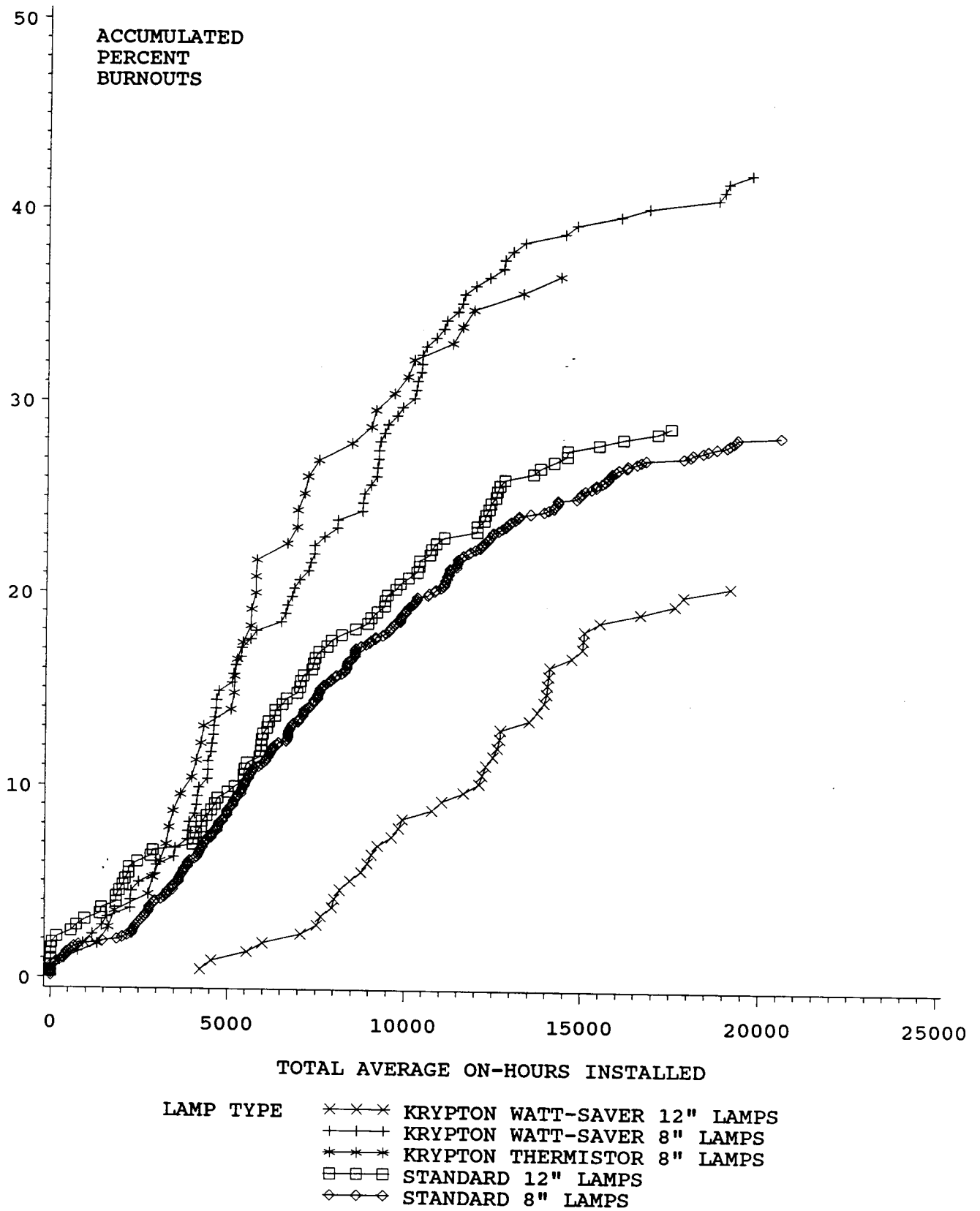
TRAFFIC SIGNAL LAMP CHART

FIGURE NUMBER	CASE B=BEST W=WORST	BY LT=LAMP TYPE M=MANUFACTURER	VARIABLES D=DAYS H=HOURS C=CYCLES	INSTALLATION TYPE T=TRAFFIC F=FLASHER	SIGNAL FACE SIZE 8 INCH 12 INCH	REMARKS
1	B	LT	D	T,F	8,12	
2	B	LT	H	T,F	8,12	
3	B	LT	C	T	8,12	
4	B	LT	C	F	8,12	
5	B	LT	D	F	8,12	
6	B	LT	H	F	8,12	
7	B	M	D	T,F	12	
8	B	M	H	T,F	12	
9	B	M	C	T	12	
10	B	M	D	F	12	
11	B	M	H	F	12	
12	B	M	C	F	12	
13	B	M	D	T,F	8	
14	B	M	H	T,F	8	
15	B	M	C	T	8	
16	B	M	D	F	8	
17	B	M	H	F	8	
18	B	M	C	F	8	
19	B	M	D	T,F	8	STANDARD LAMPS NEW VS OLD FROM SYLVANIA AND WESTINGHOUSE.
20	B	M	H	T,F	8	
21	B	M	C	T	8	
22	B	M	D	T,F	8	BY VOLTS,WATTS,AND FILAMENT SUPPORTS.
23	B	M	H	T,F	8	
24	B	M	C	T	8	
25	B,W	LT	H	T,F	8,12	WORST CASE KRYPTON WATT-SAVER 12" LAMPS ONLY.
26	W	LT	H	T,F	8,12	ALL LAMPS WORST CASE BY LAMP TYPE.
27	B	LT	H	T,F	8,12	FIGURE 2 TRUNCATED AT 6000 HOURS.
28	B	LT	H	T,F	8,12	FIGURE 2 TRUNCATED AT 8000 HOURS.
29	B	LT		T,F	8,12	OWNERSHIP COST AT 6000 HOURS.
30	B	LT		T,F	8,12	OWNERSHIP COST AT 8000 HOURS.

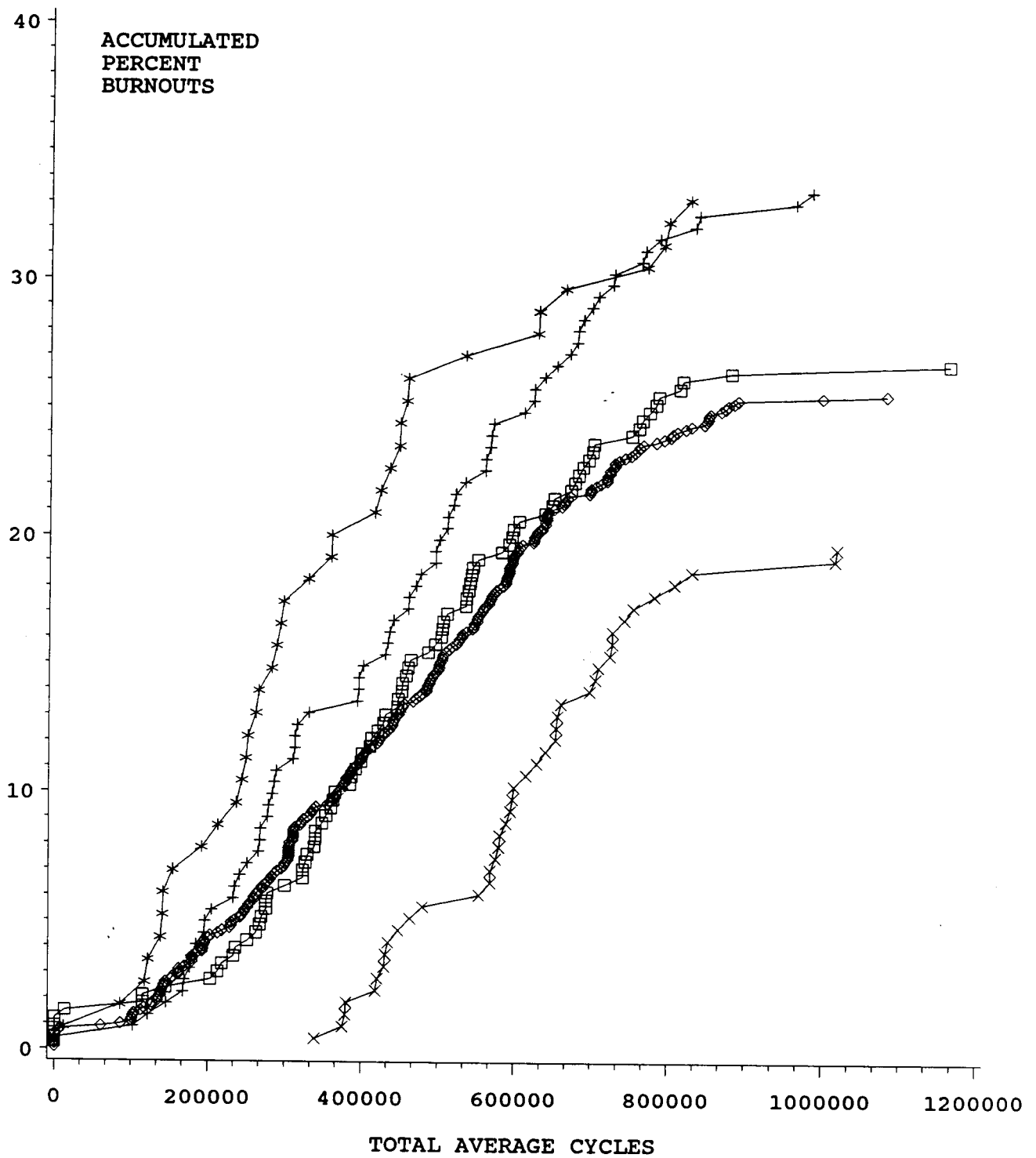
**FIGURE 1.**  
**BEST CASE BY LAMP TYPE**  
**FOR DAYS INSTALLED TEST 1**



**FIGURE 2.**  
**BEST CASE BY LAMP TYPE**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED TEST 1**

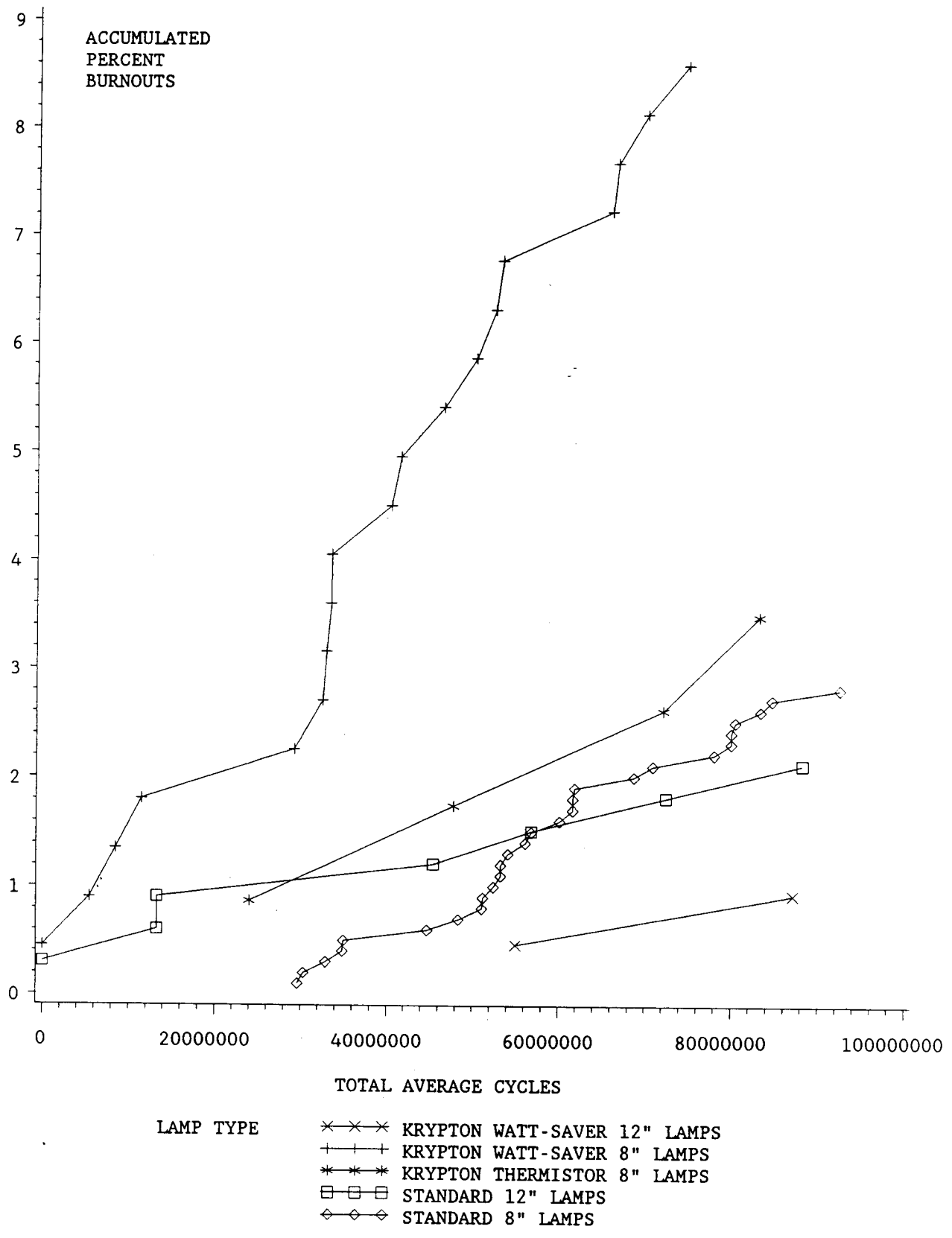


**FIGURE 3.**  
**BEST CASE BY LAMP TYPE**  
**FOR TOTAL AVERAGE CYCLES TRAFFIC ONLY TEST 1**

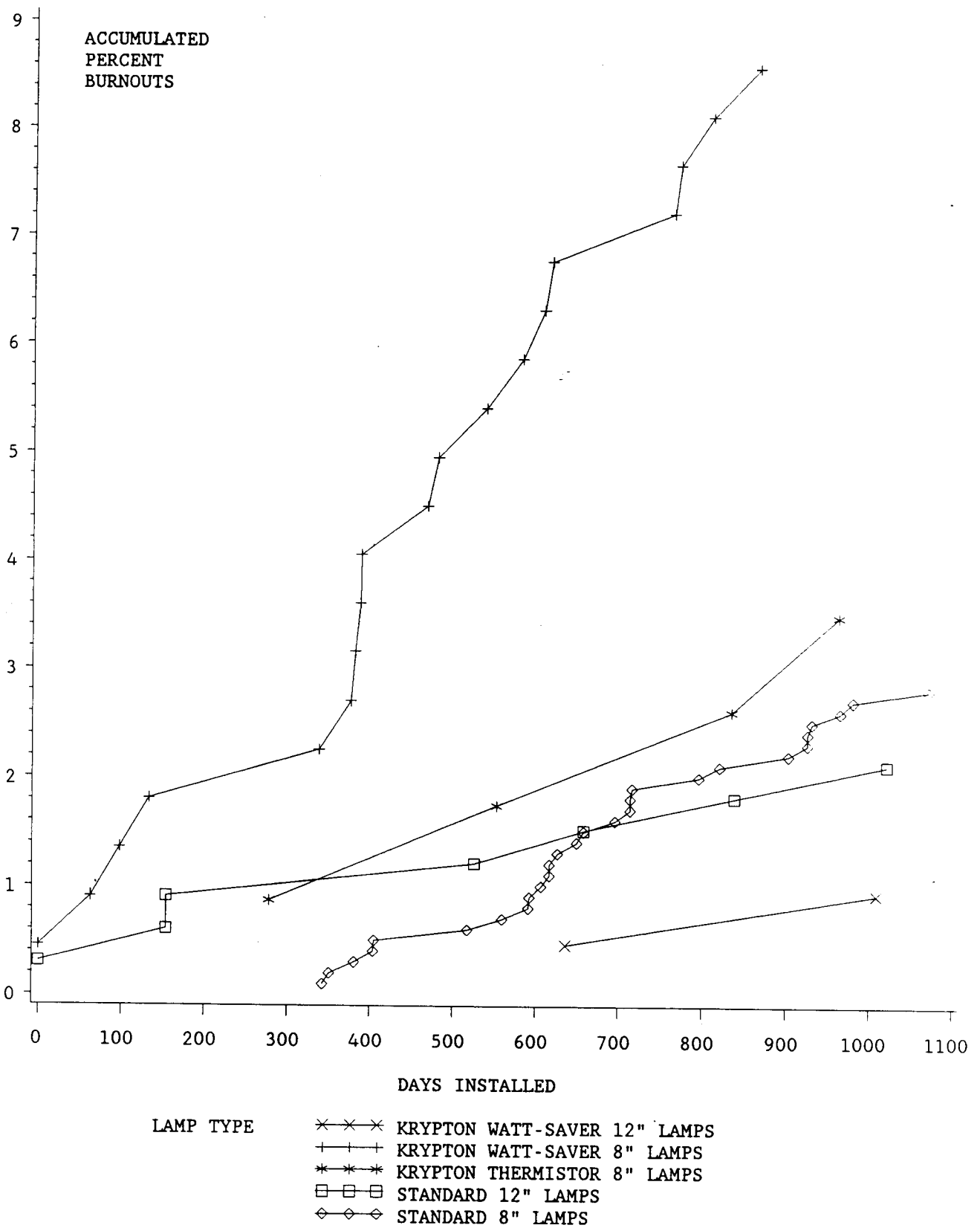


<b>LAMP TYPE</b>	*-*-*	KRYPTON WATT-SAVER 12" LAMPS
	+ + +	KRYPTON WATT-SAVER 8" LAMPS
	* * *	KRYPTON THERMISTOR 8" LAMPS
	□ □ □	STANDARD 12" LAMPS
	◇ ◇ ◇	STANDARD 8" LAMPS

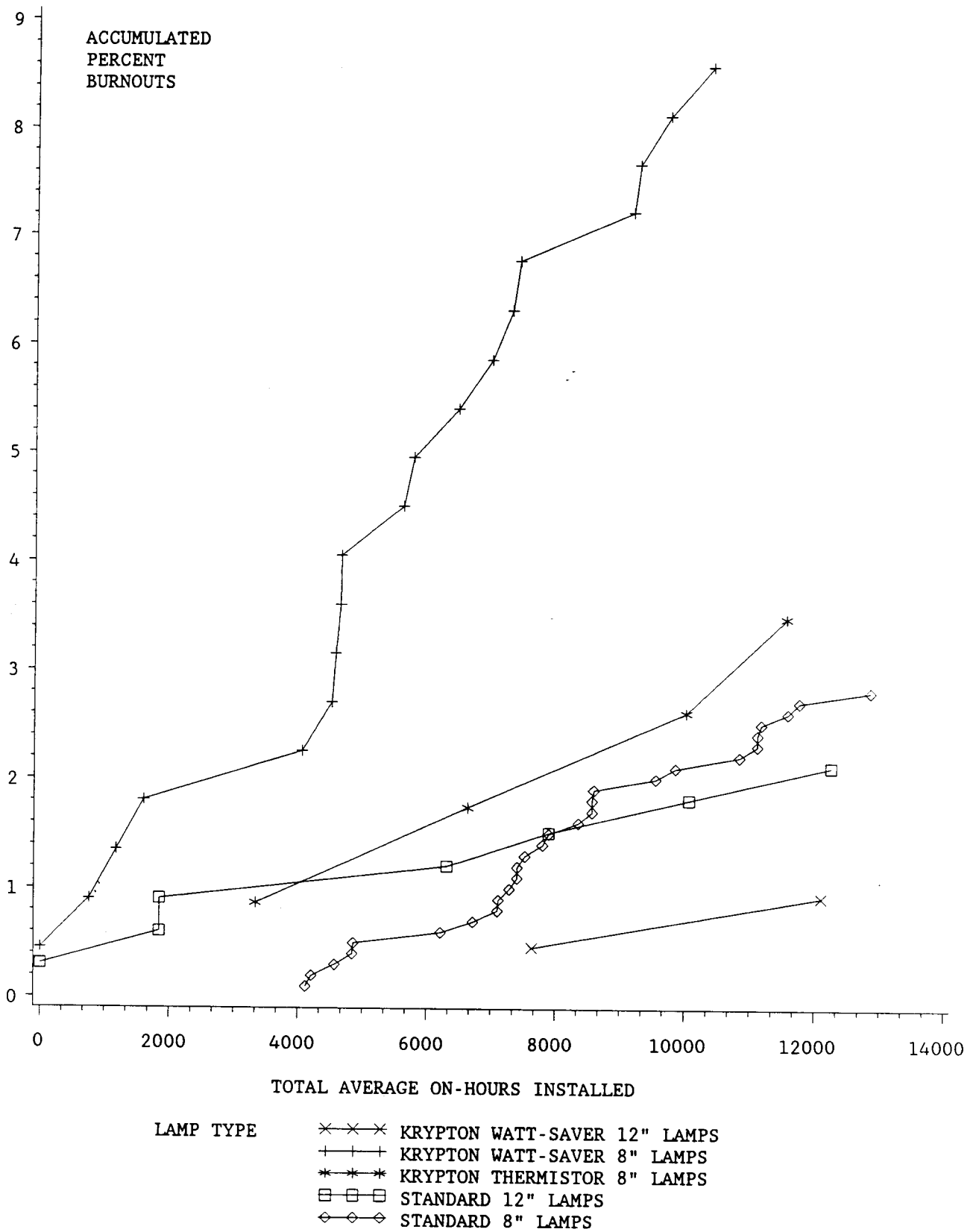
**FIGURE 4.**  
**BEST CASE BY LAMP TYPE**  
**FOR TOTAL AVERAGE CYCLES FLASHERS ONLY TEST 1**



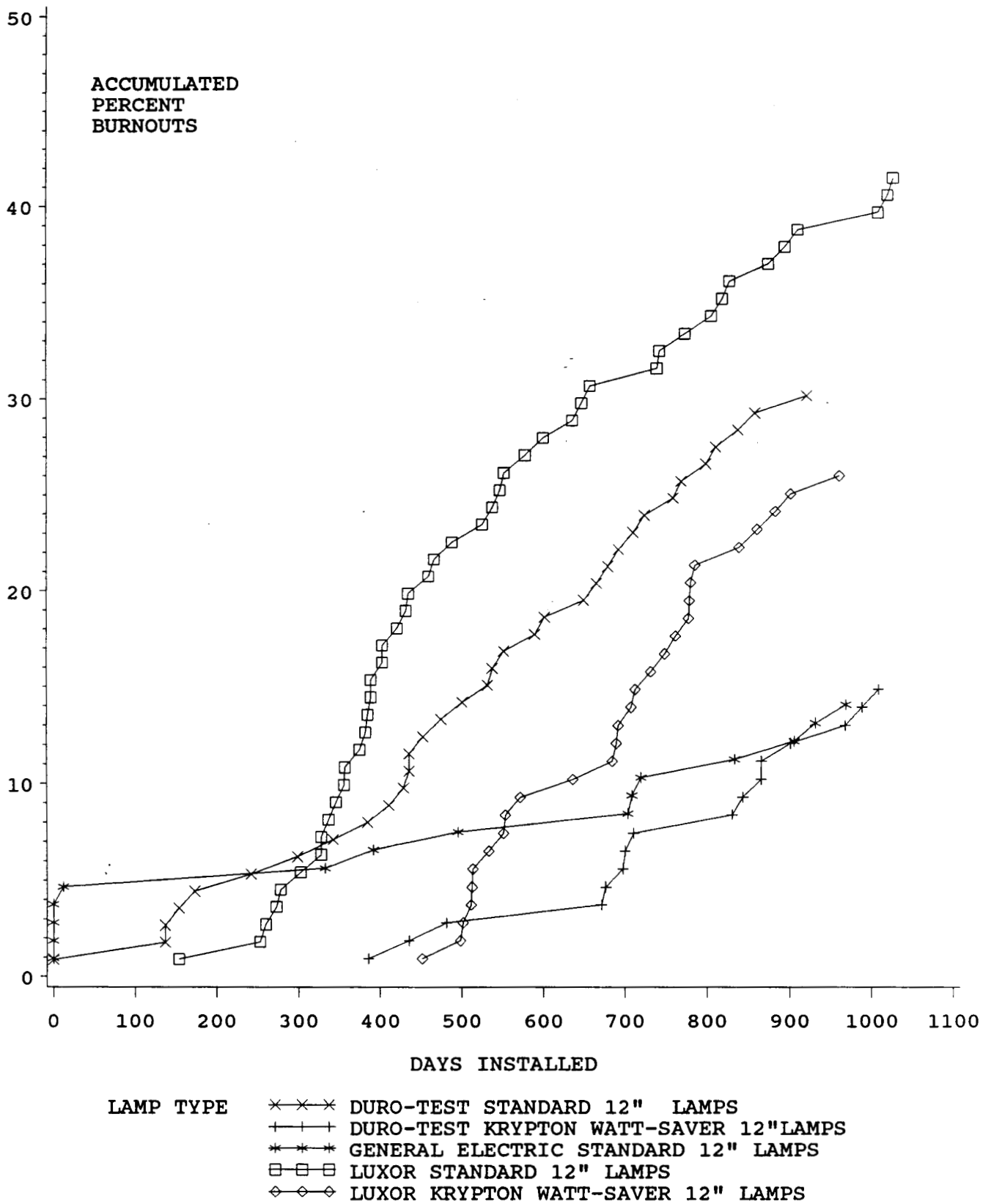
**FIGURE 5.**  
**BEST CASE BY LAMP TYPE**  
**FOR DAYS INSTALLED FLASHERS ONLY TEST 1**



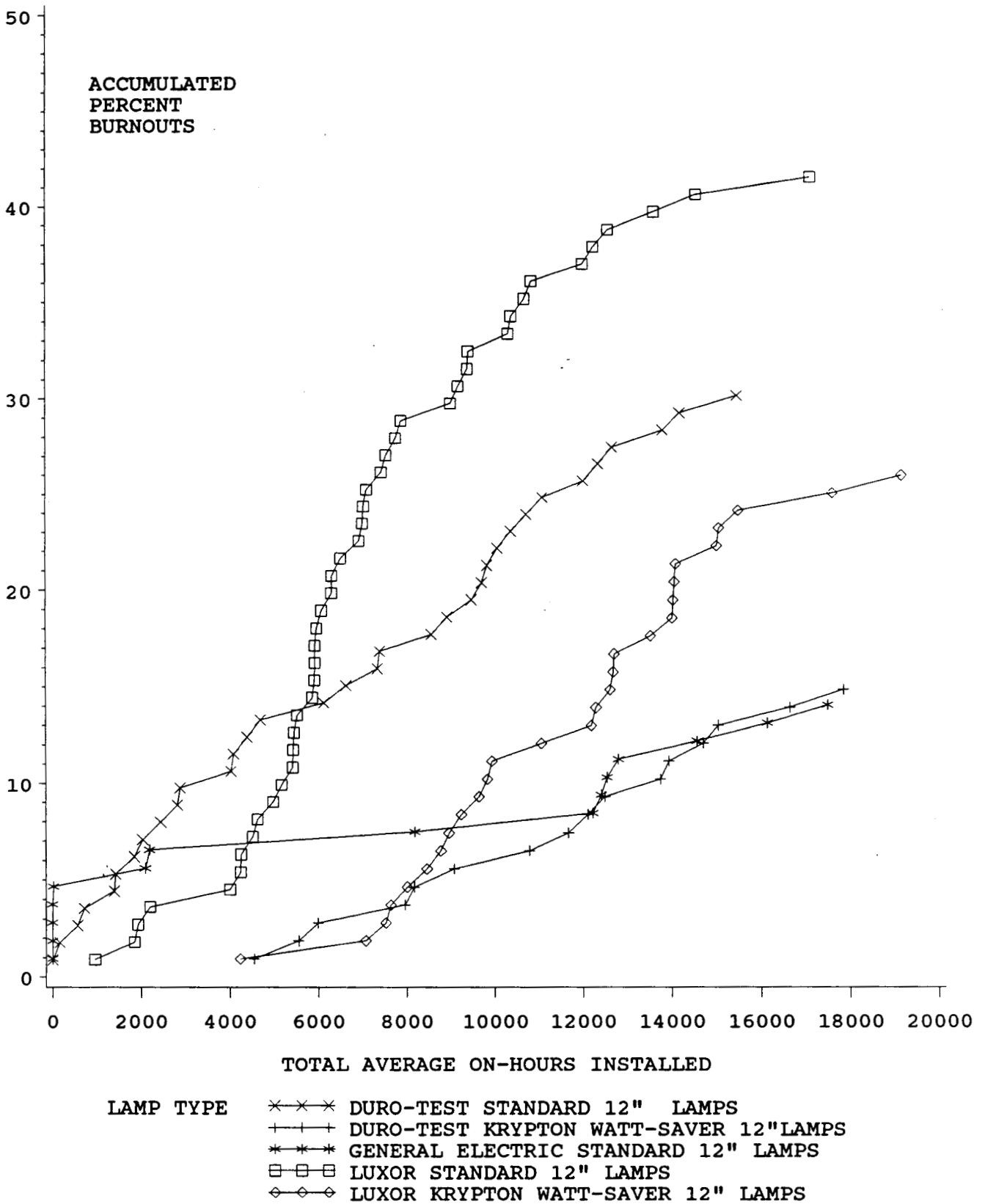
**FIGURE 6.**  
**BEST CASE BY LAMP TYPE**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED FLASHERS ONLY TEST 1**



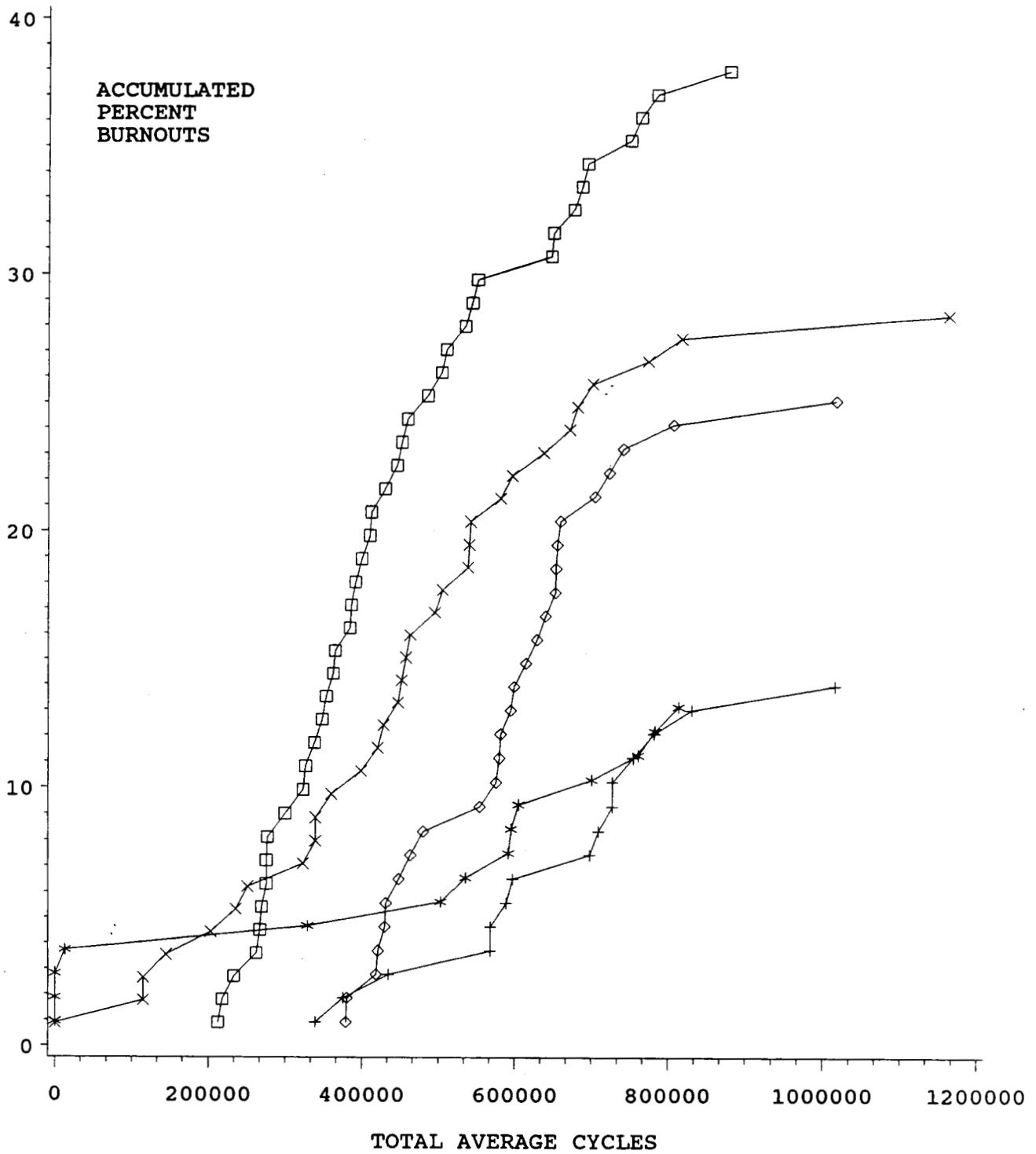
**FIGURE 7.**  
**BEST CASE BY MANUFACTURER**  
**FOR DAYS INSTALLED 12" LAMPS TEST 1**



**FIGURE 8.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED 12" LAMPS TEST 1**



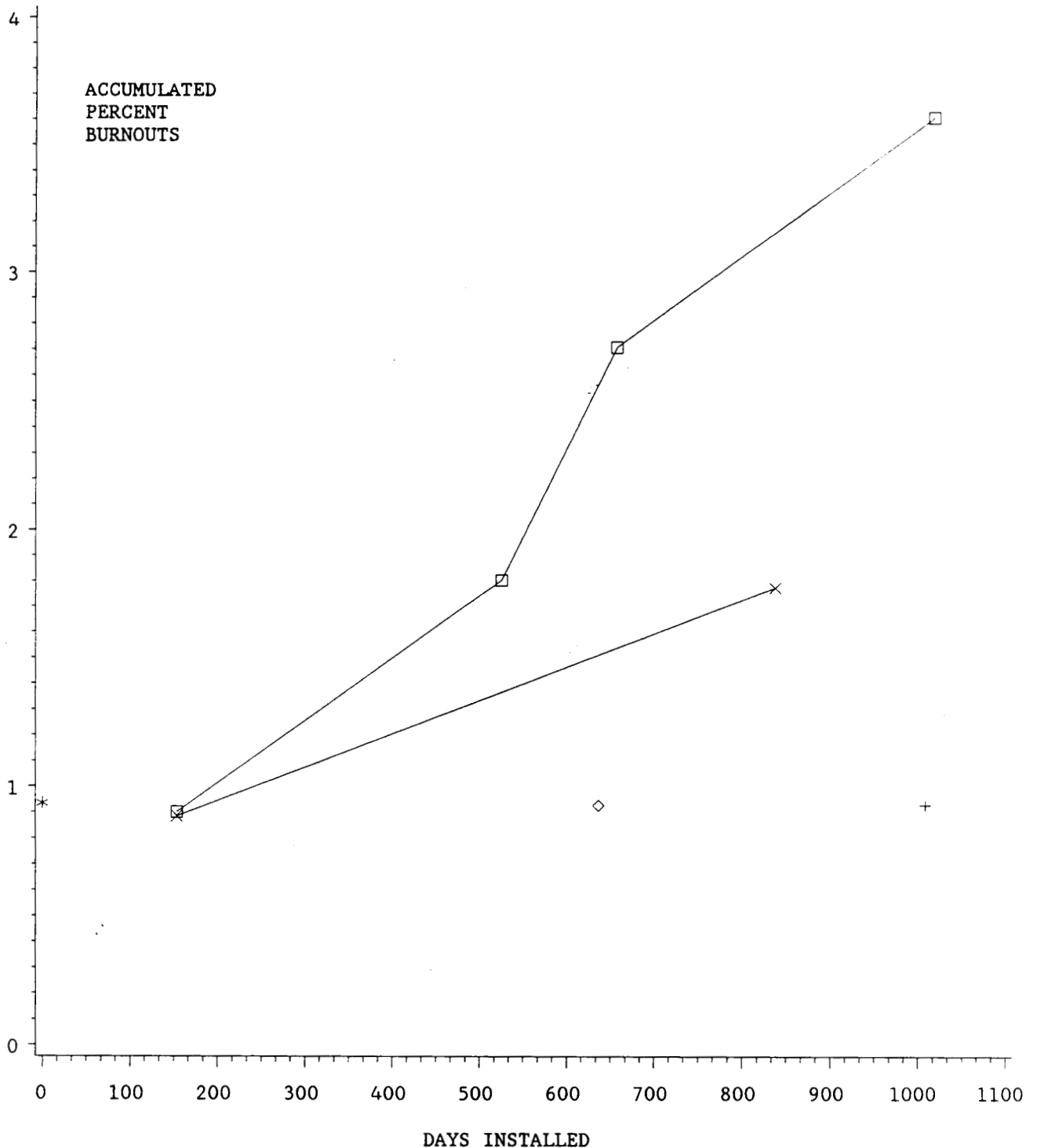
**FIGURE 9.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE CYCLES TRAFFIC ONLY 12" LAMPS TEST 1**



**LAMP TYPE**

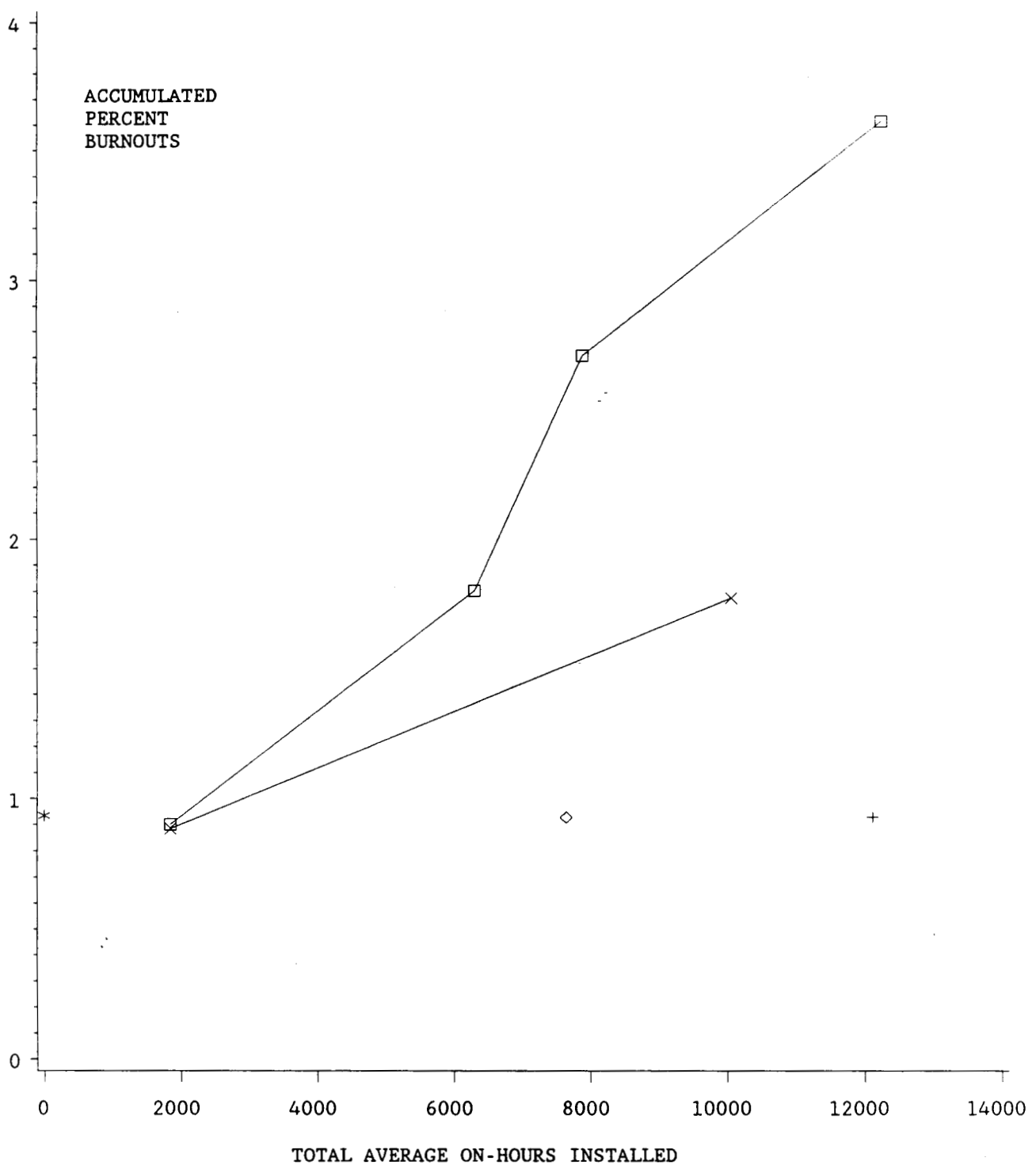
- \*-\*-\* DURO-TEST STANDARD 12" LAMPS
- +--+ DURO-TEST KRYPTON WATT-SAVER 12" LAMPS
- \*-\*-\* GENERAL ELECTRIC STANDARD 12" LAMPS
- LUXOR STANDARD 12" LAMPS
- ◇-◇-◇ LUXOR KRYPTON WATT-SAVER 12" LAMPS

**FIGURE 10.**  
**BEST CASE BY MANUFACTURER**  
**FOR DAYS INSTALLED 12" LAMPS FLASHERS ONLY TEST 1**



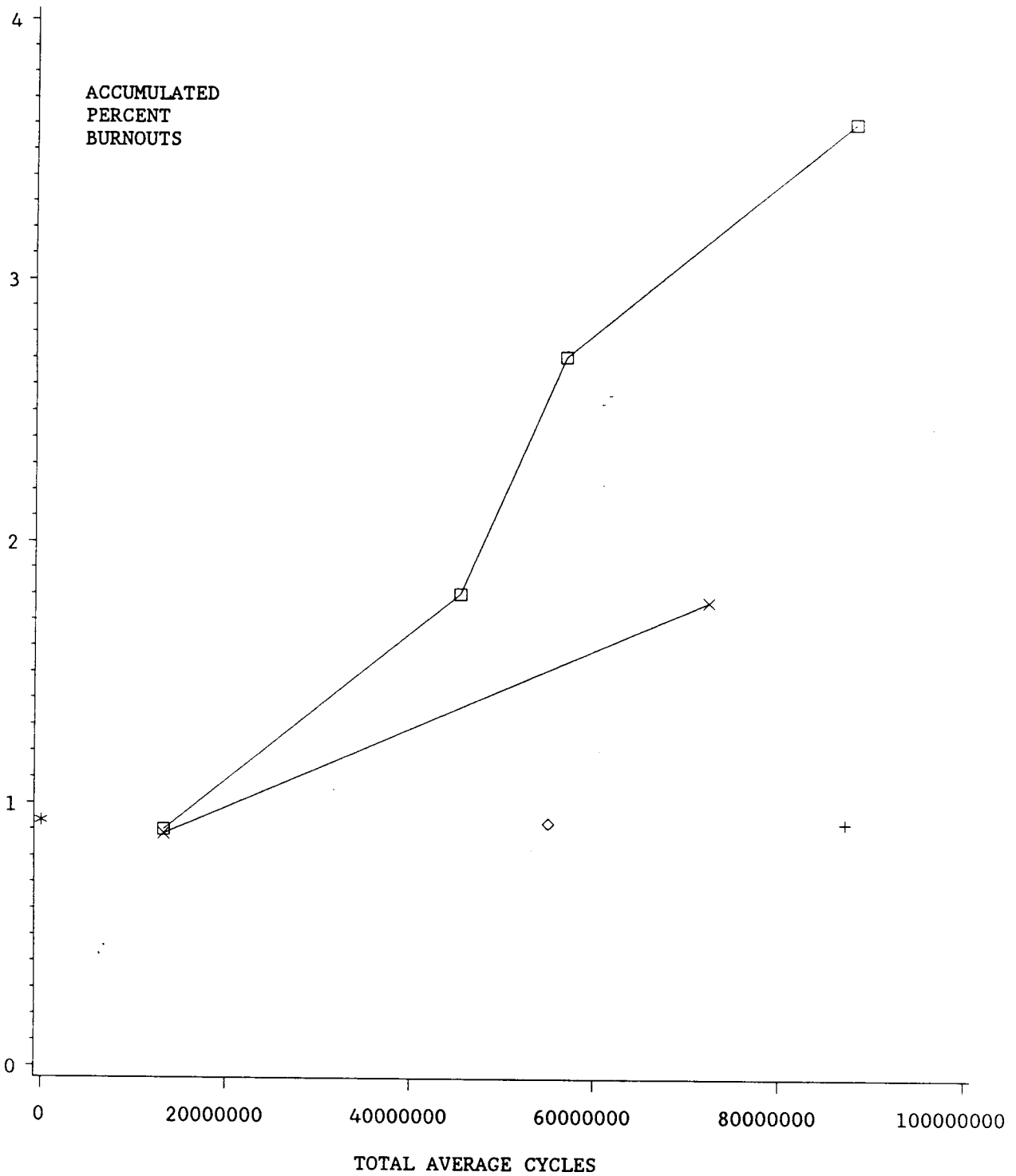
LAMP TYPE      ×-×-× DURO-TEST STANDARD 12" LAMPS  
 +--+ DURO-TEST KRYPTON WATT-SAVER 12" LAMPS  
 \*-\*- GENERAL ELECTRIC STANDARD 12" LAMPS  
 □-□-□ LUXOR STANDARD 12" LAMPS  
 ◇-◇-◇ LUXOR KRYPTON WATT-SAVER 12" LAMPS

**FIGURE 11.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED 12" LAMPS FLASHERS ONLY TEST 1**



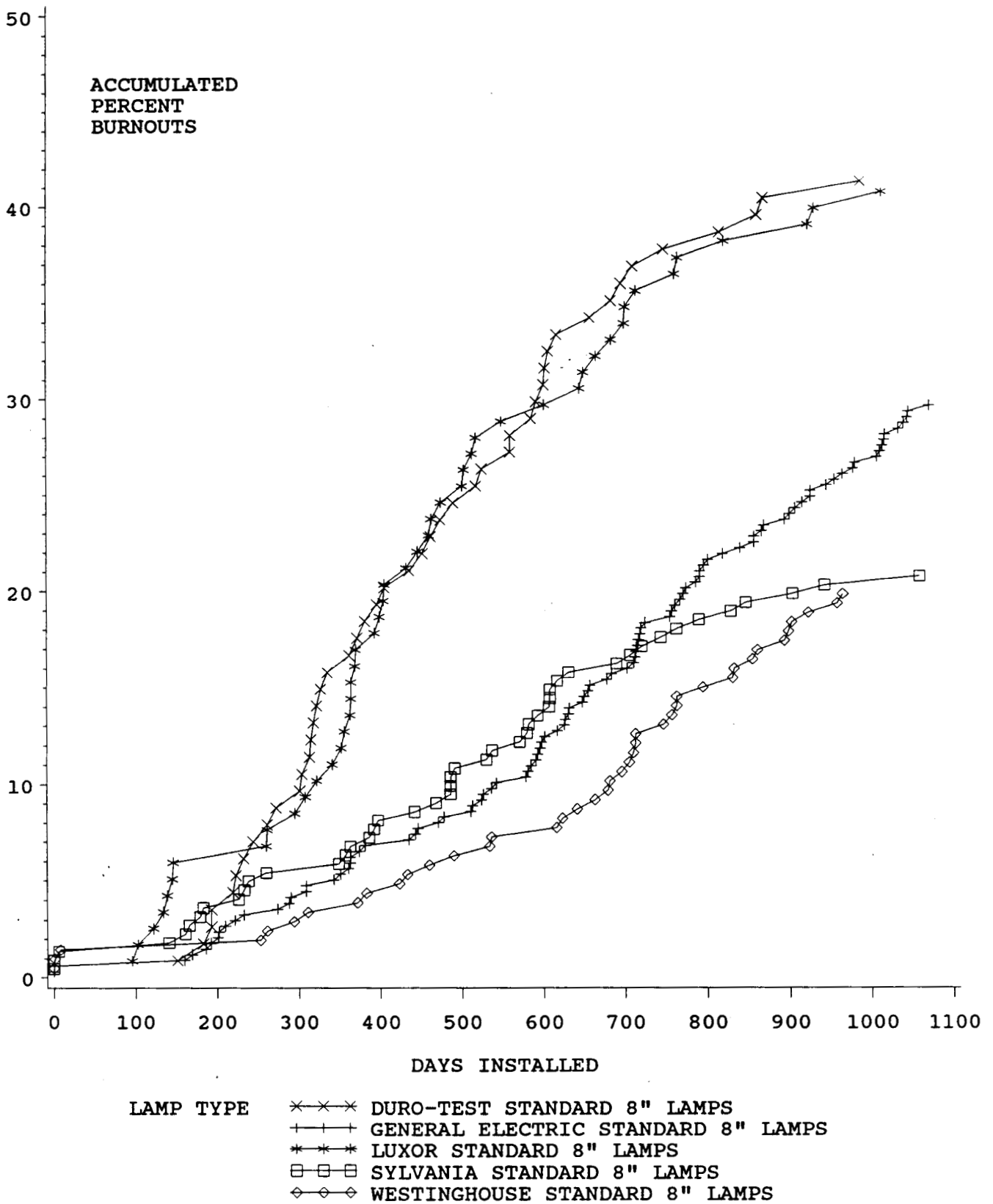
- LAMP TYPE
- ×-×-× DURO-TEST STANDARD 12" LAMPS
  - +--+ DURO-TEST KRYPTON WATT-SAVER 12"LAMPS
  - \*-\*-\* GENERAL ELECTRIC STANDARD 12" LAMPS
  - LUXOR STANDARD 12" LAMPS
  - ◇-◇-◇ LUXOR KRYPTON WATT-SAVER 12" LAMPS

**FIGURE 12.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE CYCLES FLASHERS ONLY 12" LAMPS TEST 1**

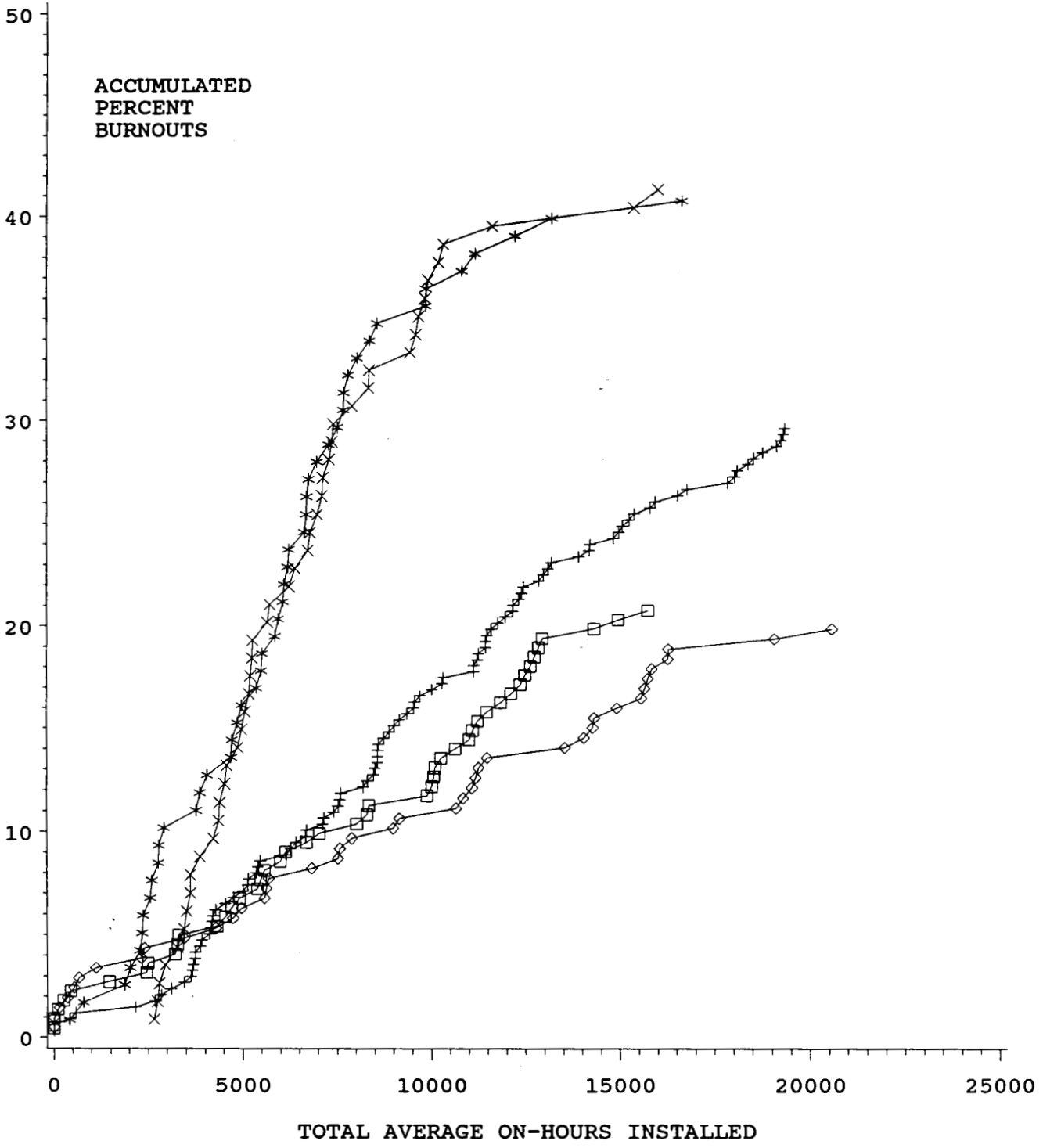


LAMP TYPE      \*-\*-\* DURO-TEST STANDARD 12" LAMPS  
 +--+ DURO-TEST KRYPTON WATT-SAVER 12" LAMPS  
 \*-\*-\* GENERAL ELECTRIC STANDARD 12" LAMPS  
 □-□-□ LUXOR STANDARD 12" LAMPS  
 ◇-◇-◇ LUXOR KRYPTON WATT-SAVER 12" LAMPS

**FIGURE 13.**  
**BEST CASE BY MANUFACTURER**  
**FOR DAYS INSTALLED STANDARD 8" LAMPS TEST 1**



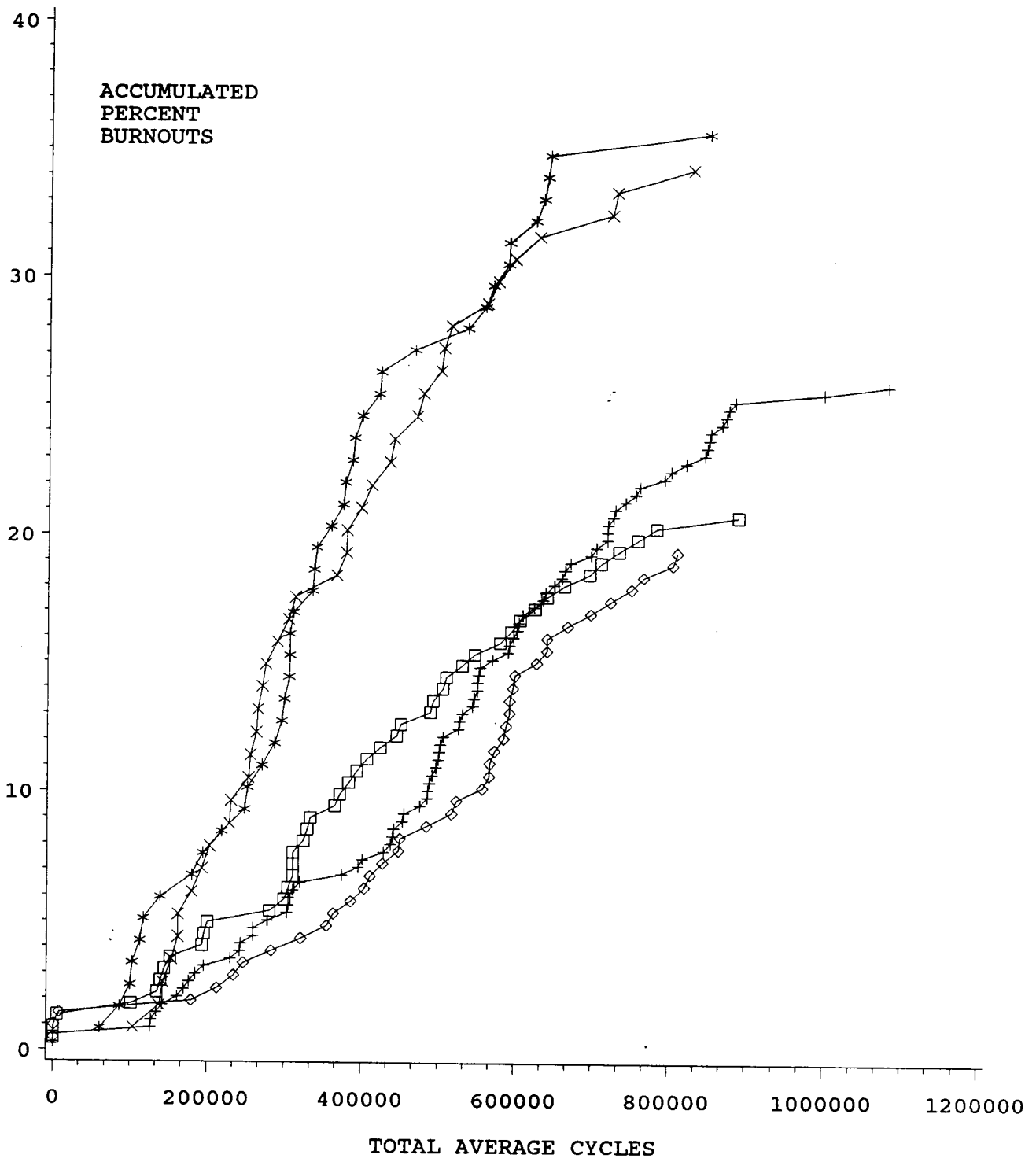
**FIGURE 14.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED STANDARD 8" LAMPS TEST 1**



**LAMP TYPE**

- \*-\*-\* DUORO-TEST STANDARD 8" LAMPS
- +--+ GENERAL ELECTRIC STANDARD 8" LAMPS
- \*-\*-\* LUXOR STANDARD 8" LAMPS
- SYLVANIA STANDARD 8" LAMPS
- ◇-◇- WESTINGHOUSE STANDARD 8" LAMPS

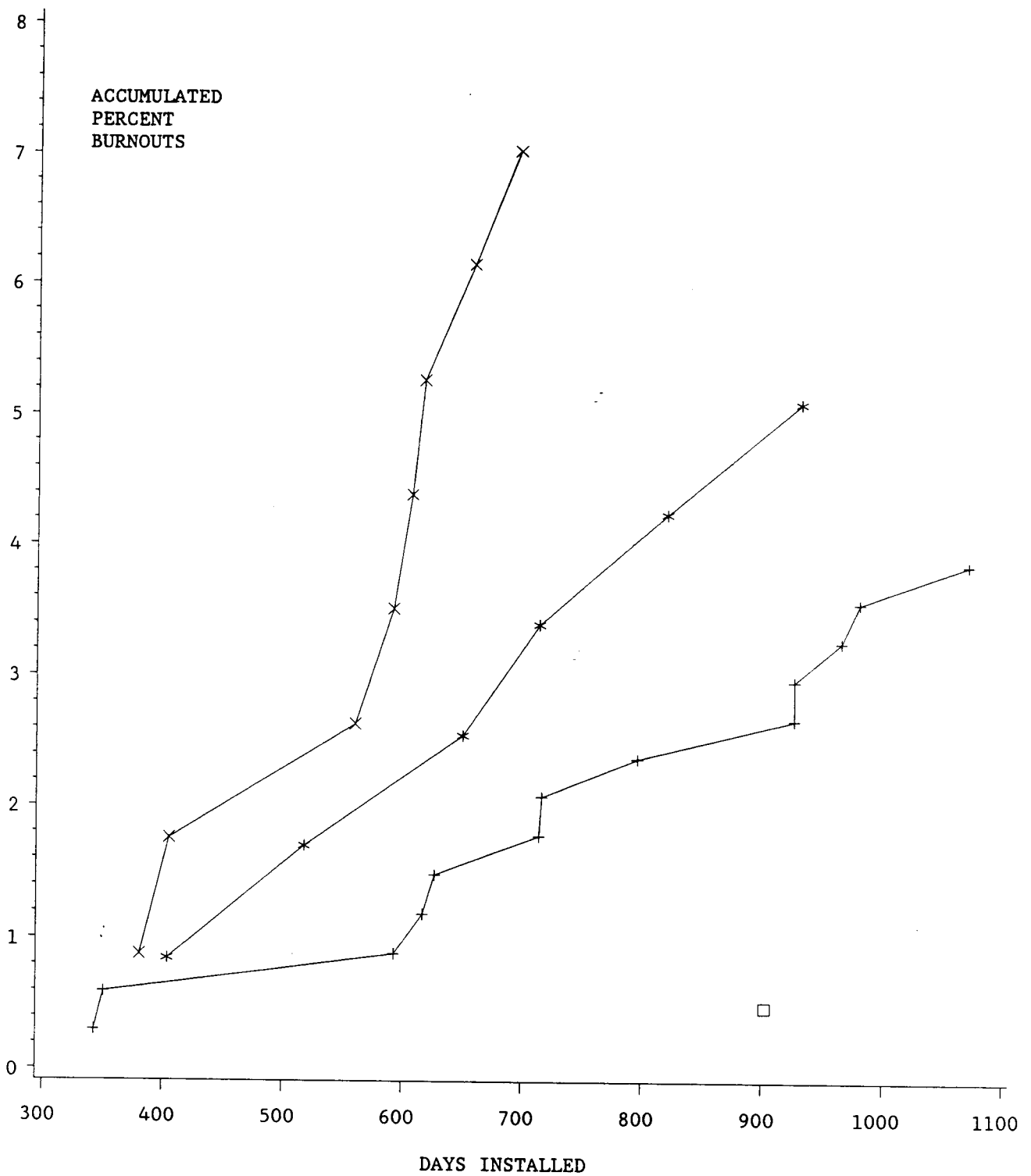
**FIGURE 15.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE CYCLES STANDARD 8" LAMPS TEST 1**



**LAMP TYPE**

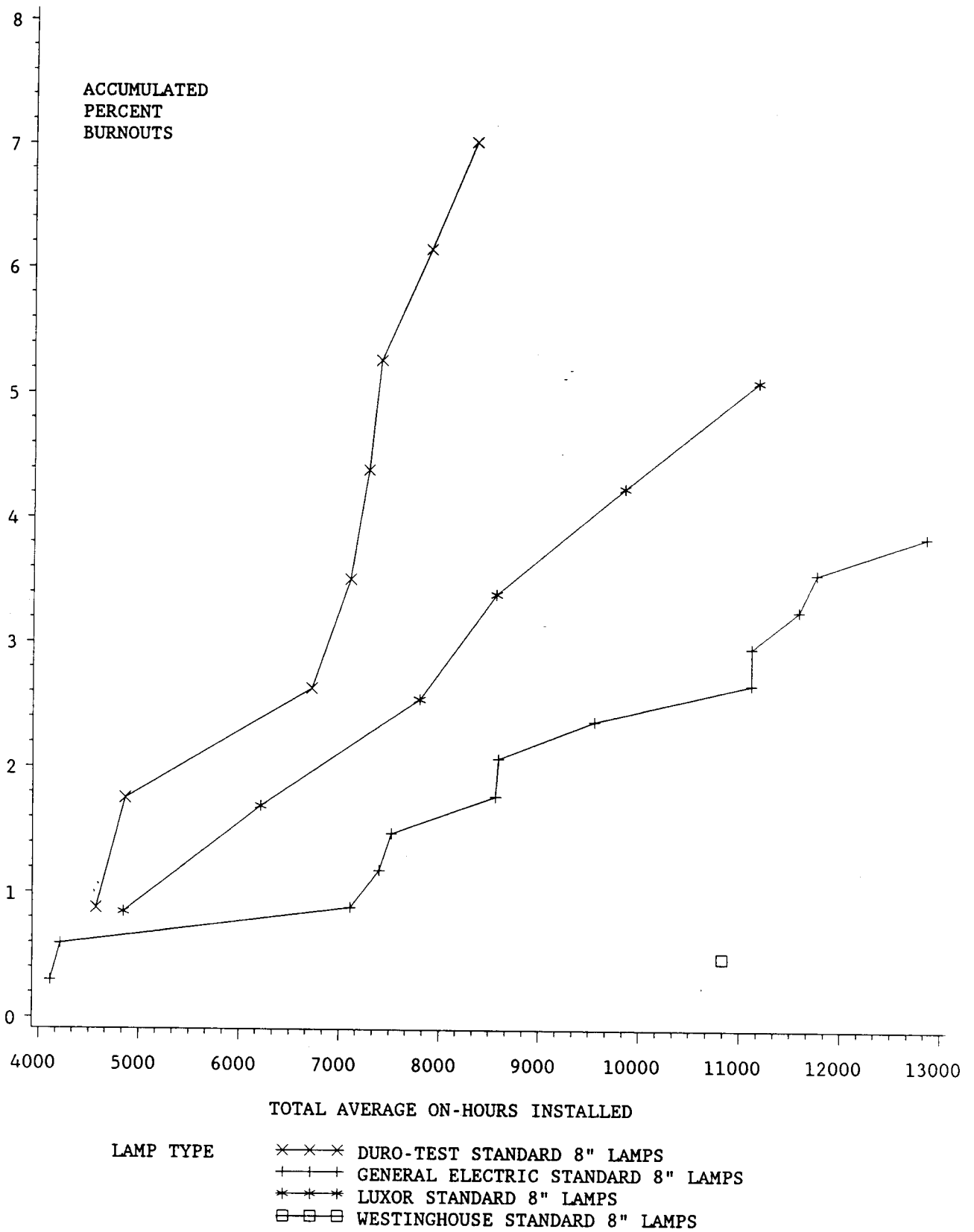
- \*-\*-\* DURO-TEST STANDARD 8" LAMPS
- + + + GENERAL ELECTRIC STANDARD 8" LAMPS
- \*-\*-\* LUXOR STANDARD 8" LAMPS
- SYLVANIA STANDARD 8" LAMPS
- ◇-◇-◇ WESTINGHOUSE STANDARD 8" LAMPS

**FIGURE 16.**  
**BEST CASE BY MANUFACTURER**  
**FOR DAYS INSTALLED STANDARD 8" LAMPS FLASHERS ONLY TEST 1**

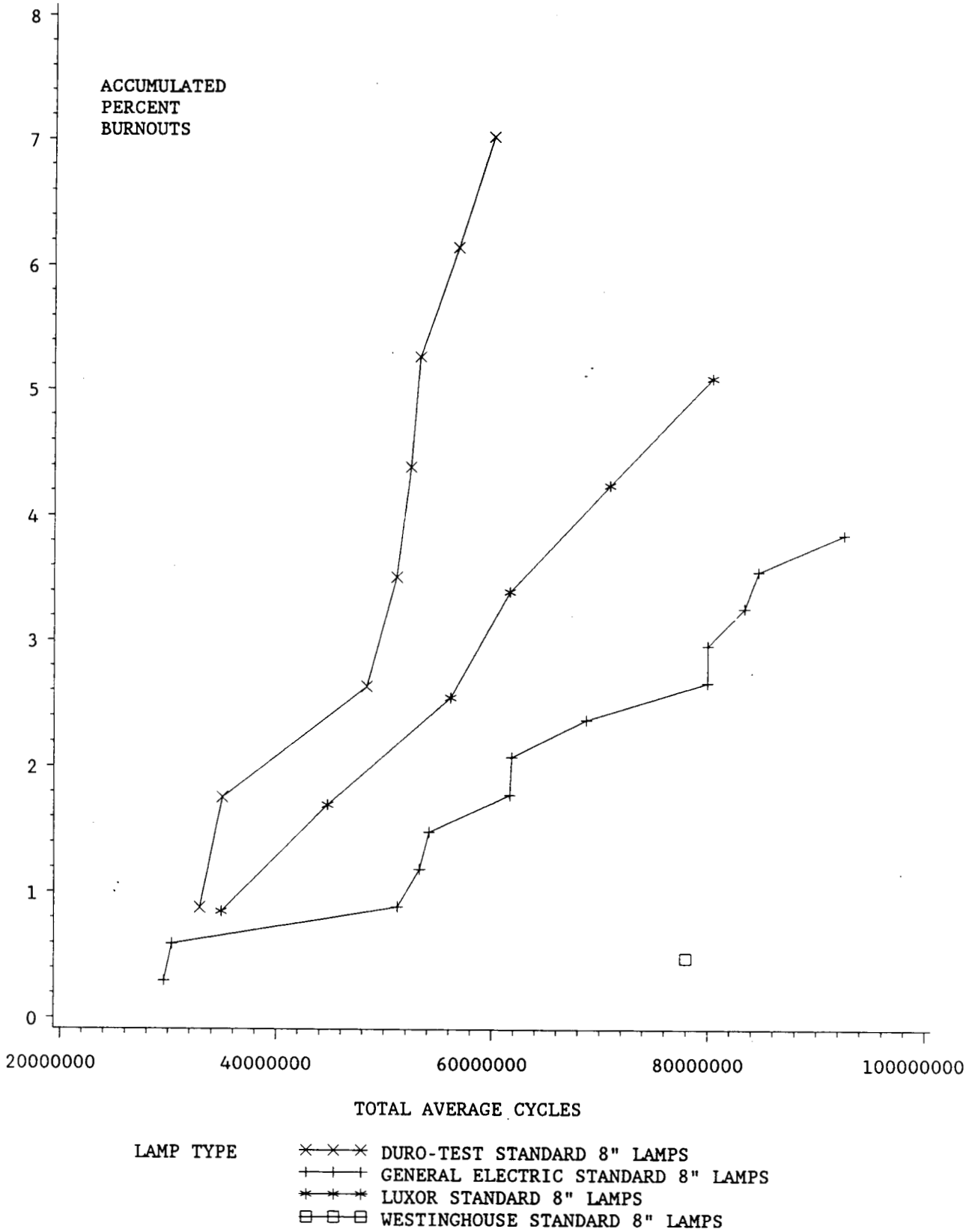


LAMP TYPE      ×-×-× DURO-TEST STANDARD 8" LAMPS  
 +--+ GENERAL ELECTRIC STANDARD 8" LAMPS  
 \*-\*- LUXOR STANDARD 8" LAMPS  
 □-□-□ WESTINGHOUSE STANDARD 8" LAMPS

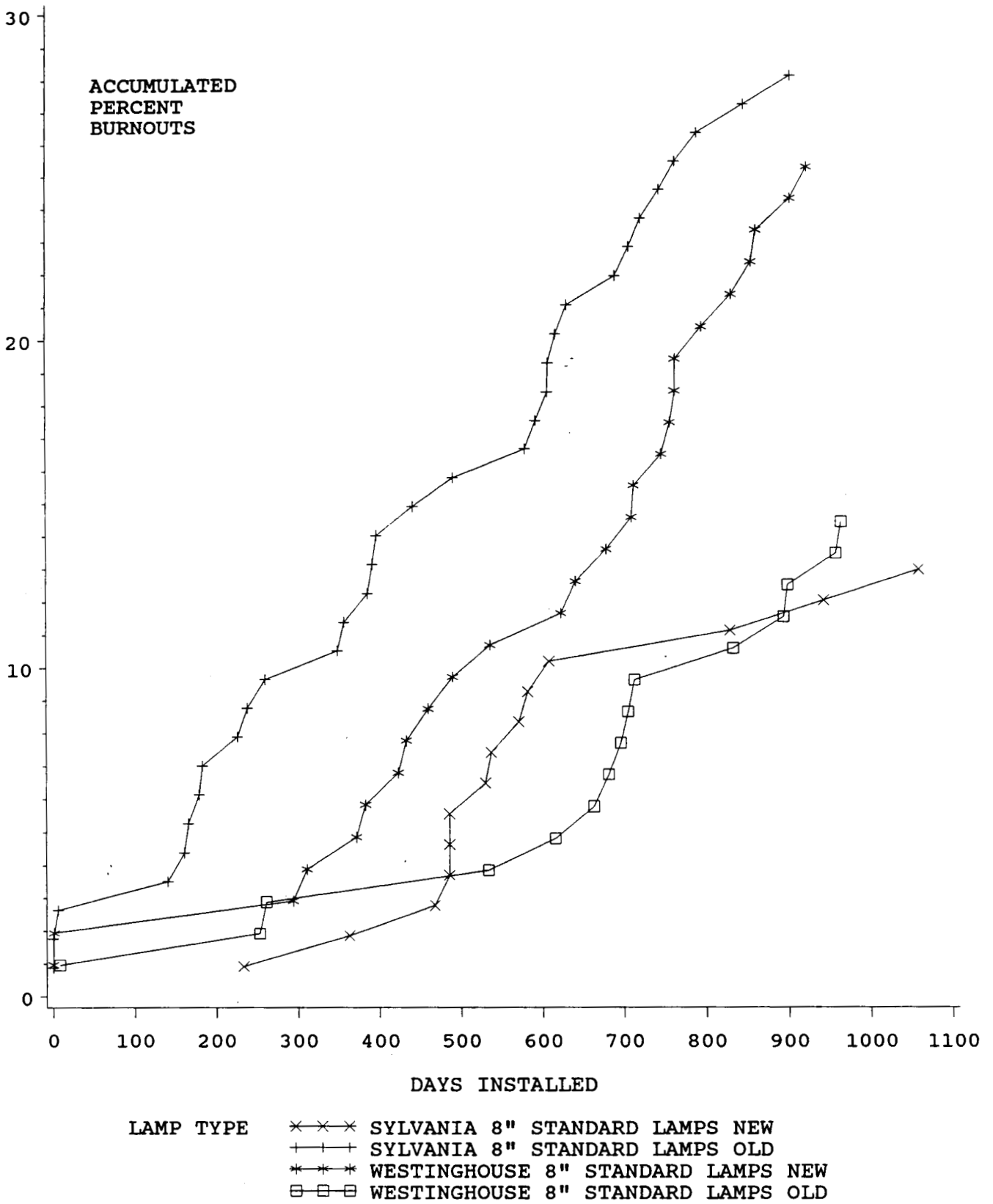
**FIGURE 17.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED STANDARD 8" LAMPS FLASHERS ONLY TEST 1**



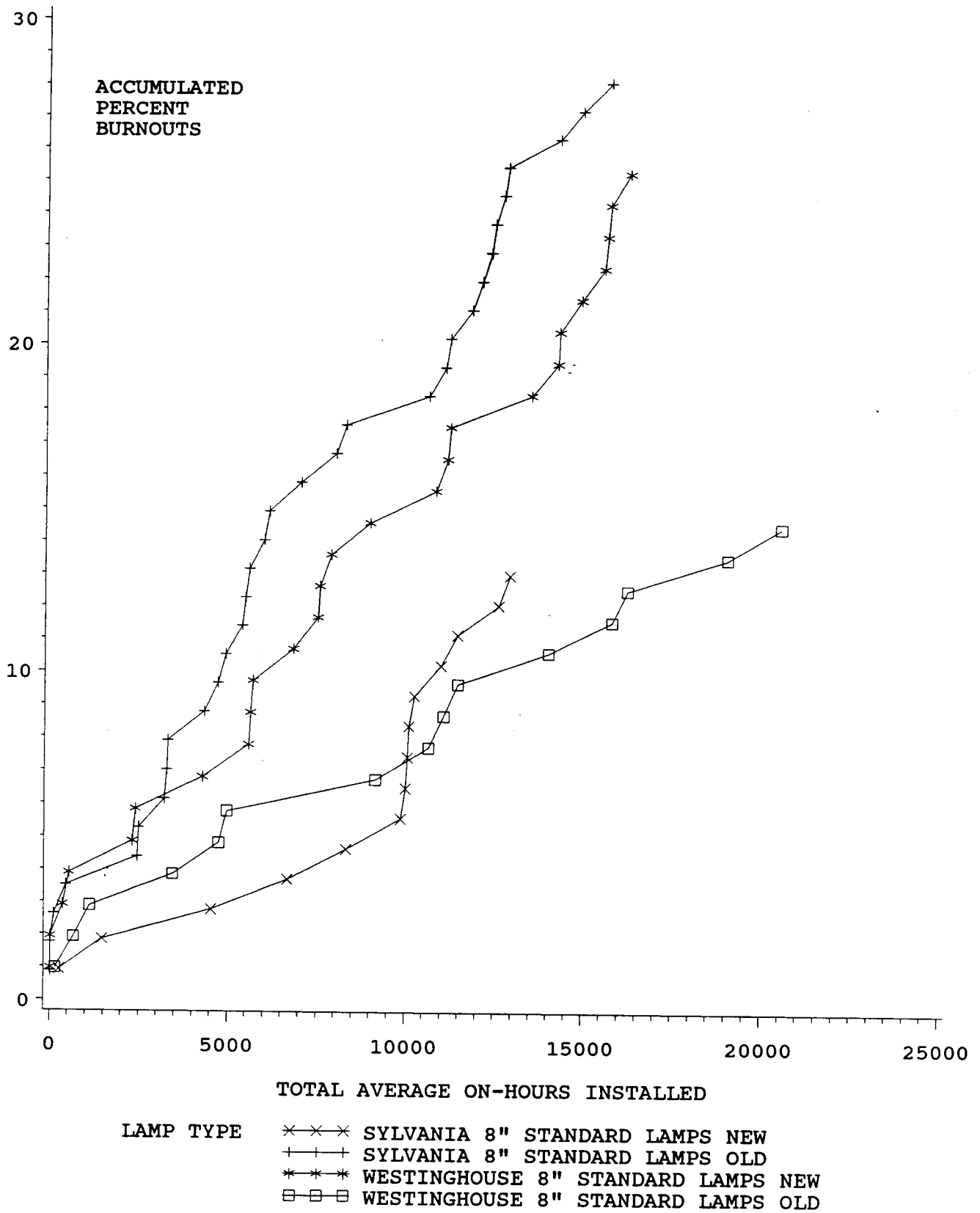
**FIGURE 18.**  
**BEST CASE BY MANUFACTURER**  
**FOR TOTAL AVERAGE CYCLES STANDARD 8" LAMPS FLASHERS ONLY TEST 1**



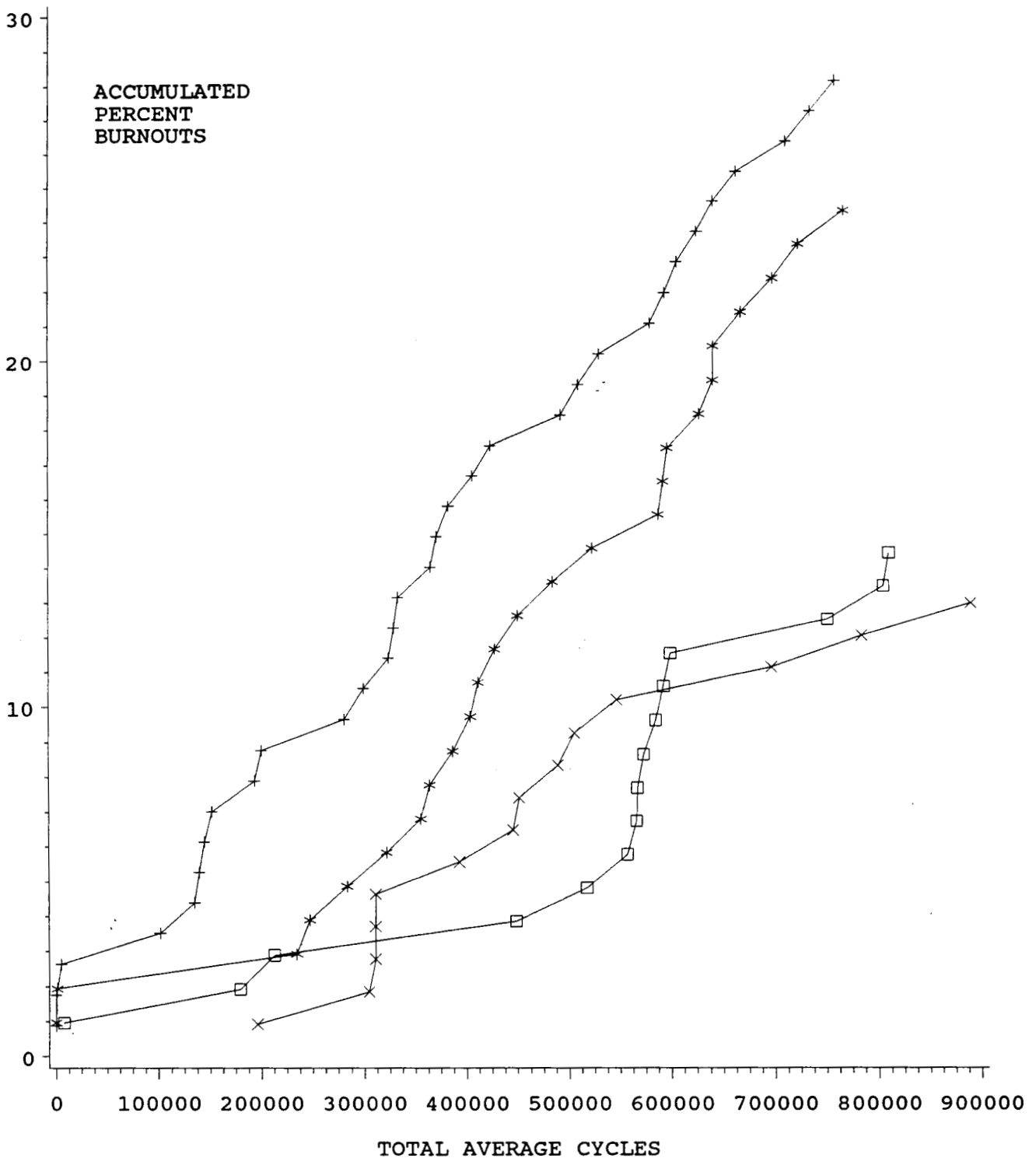
**FIGURE 19.**  
**BEST CASE BY MANUFACTURER NEW VS OLD**  
**FOR DAYS INSTALLED STANDARD 8" LAMPS TEST 1**



**FIGURE 20.**  
**BEST CASE BY MANUFACTURER NEW VS OLD**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED STANDARD 8" LAMPS TEST 1**

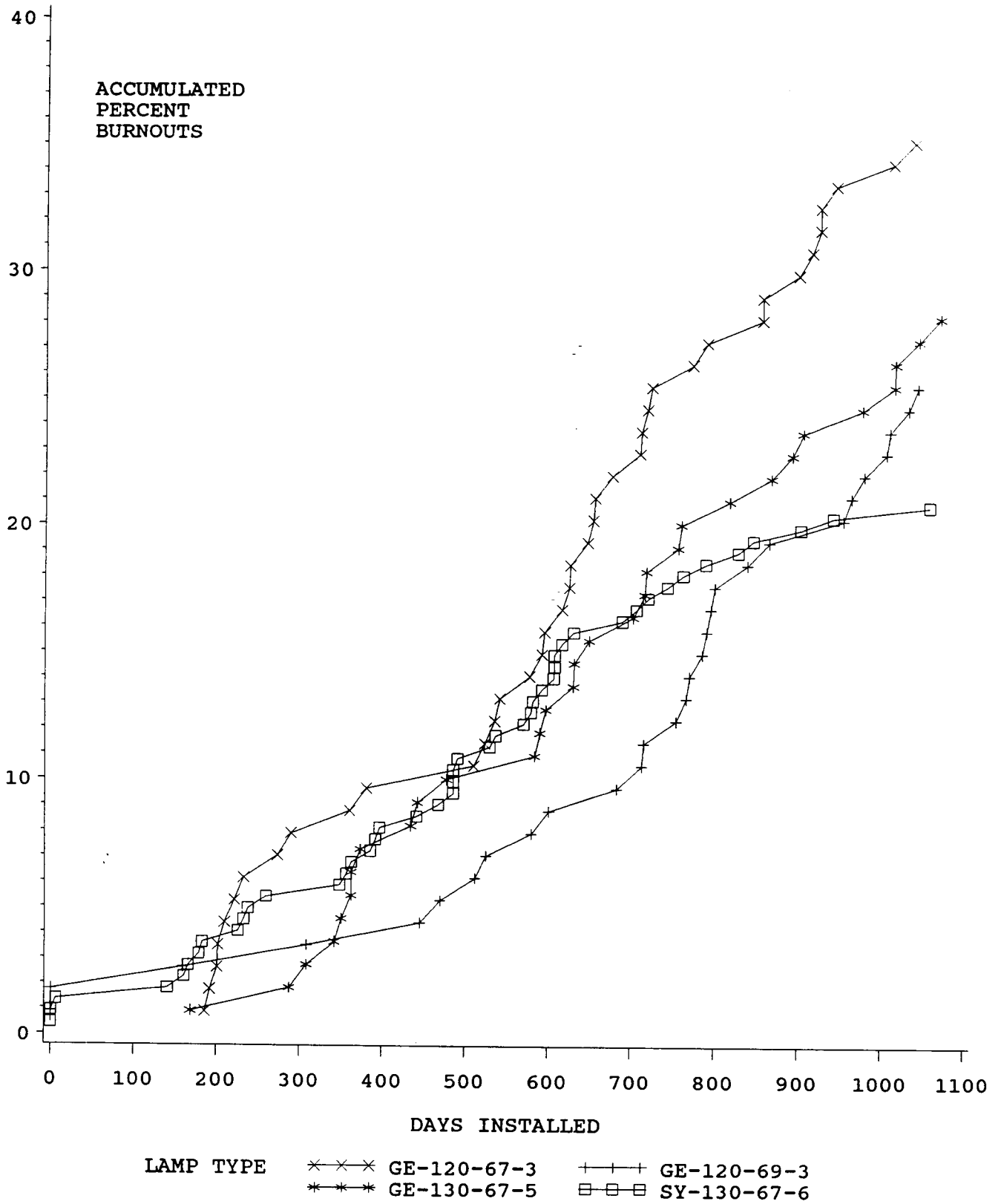


**FIGURE 21.**  
**BEST CASE BY MANUFACTURER NEW VS OLD**  
**FOR TOTAL AVERAGE CYCLES STANDARD 8" LAMPS TRAFFIC ONLY TEST 1**

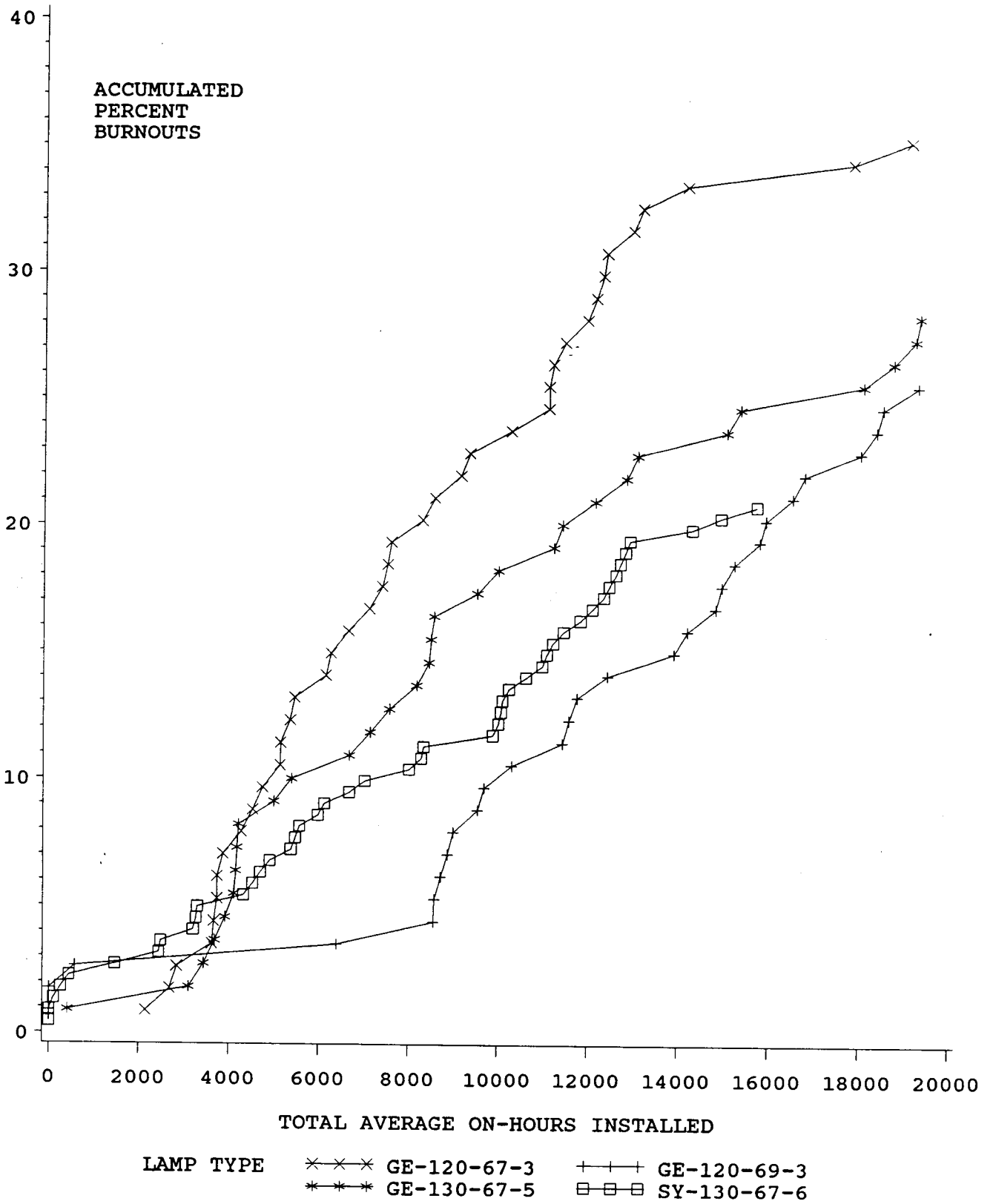


**LAMP TYPE**    x-x-x SYLVANIA 8" STANDARD LAMPS NEW  
                   +-+ SYLVANIA 8" STANDARD LAMPS OLD  
                   \*-\* WESTINGHOUSE 8" STANDARD LAMPS NEW  
                   □-□ WESTINGHOUSE 8" STANDARD LAMPS OLD

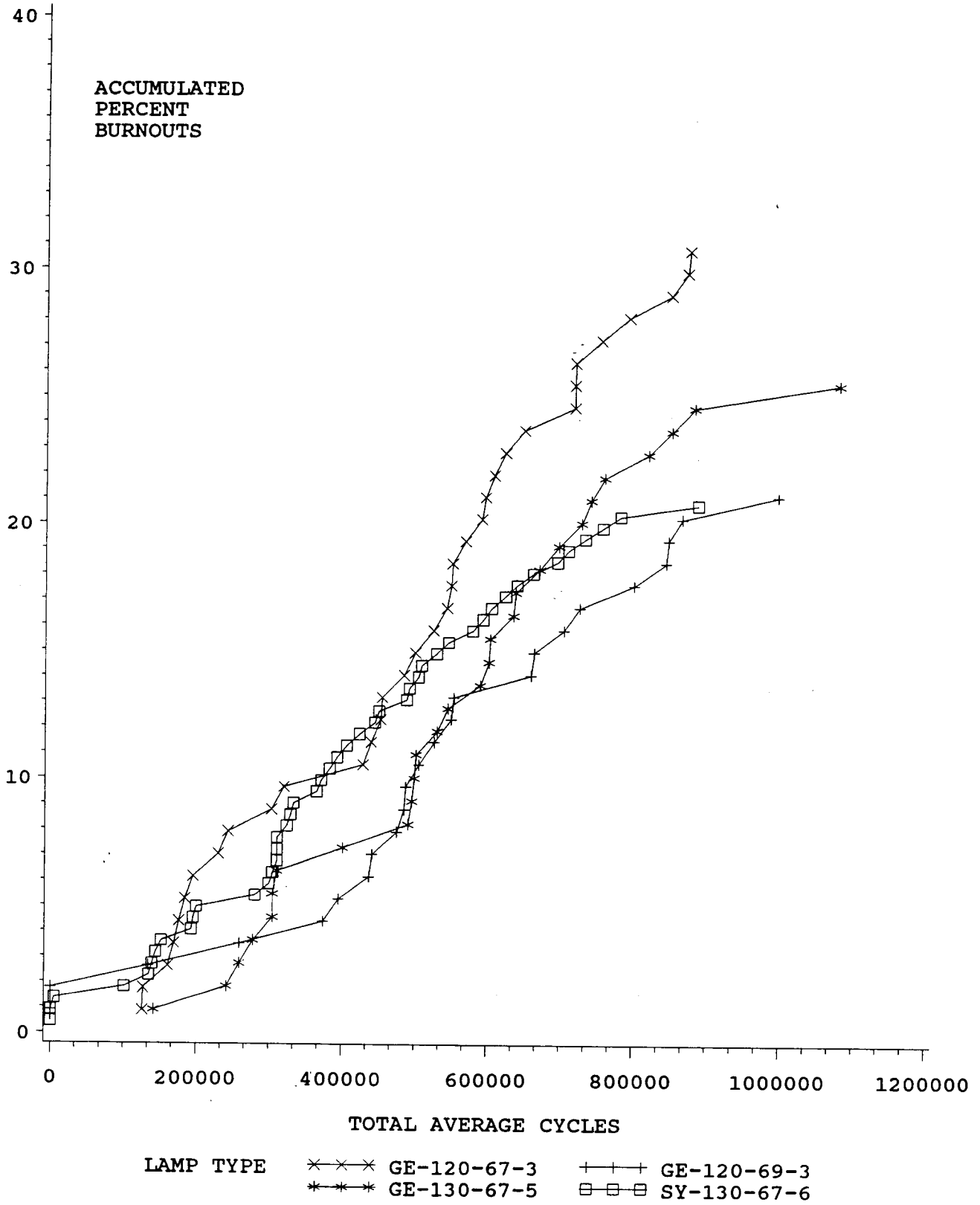
**FIGURE 22.**  
**BEST CASE BY MANUFACTURER.**  
**FOR DAYS INSTALLED STANDARD 8" LAMPS TEST 1**  
**BY VOLTS, WATTS AND FILAMENT SUPPORTS**



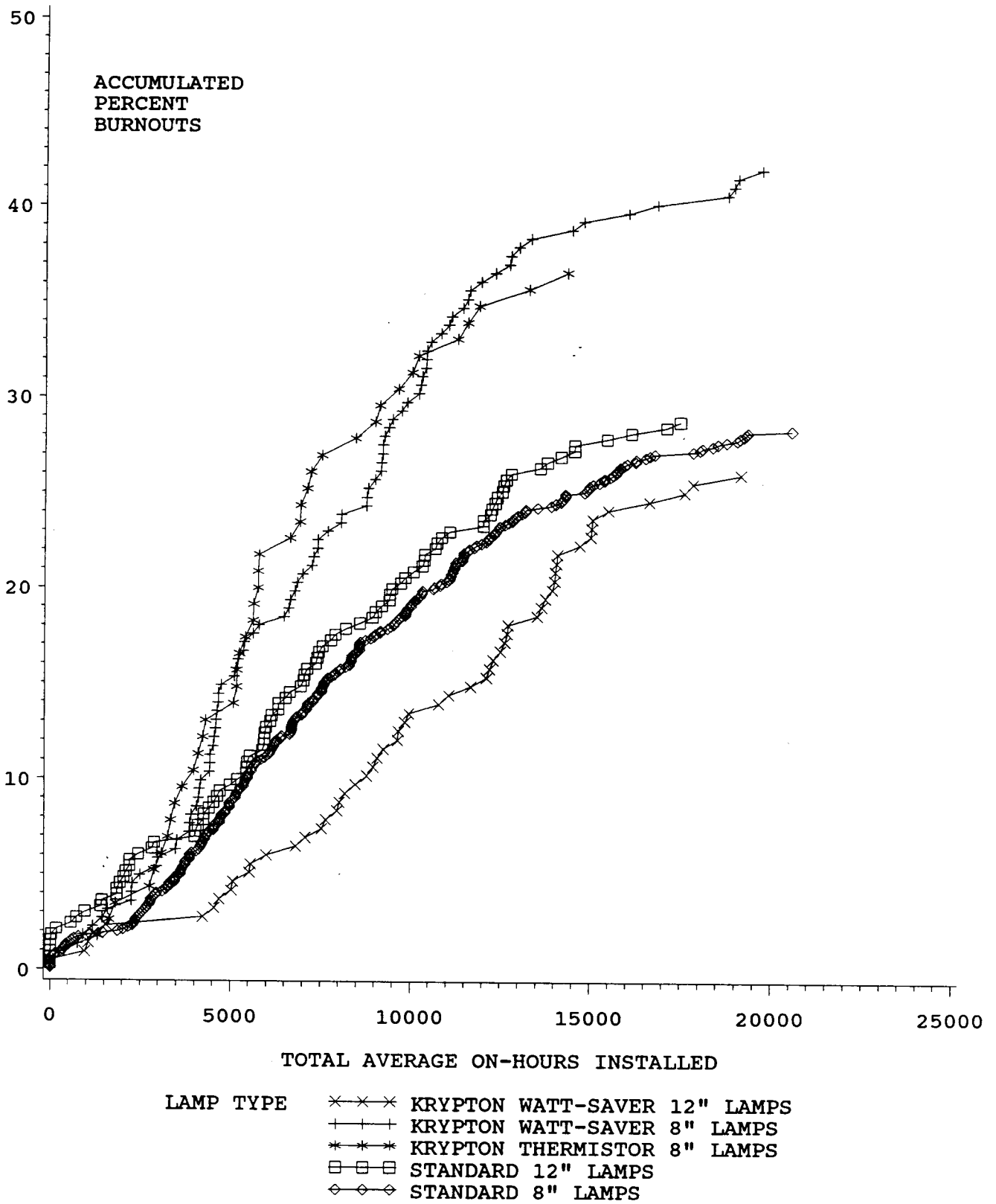
**FIGURE 23.**  
**BEST CASE BY MANUFACTURER.**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED STANDARD 8" LAMPS TEST 1**  
**BY VOLTS, WATTS AND FILAMENT SUPPORTS**



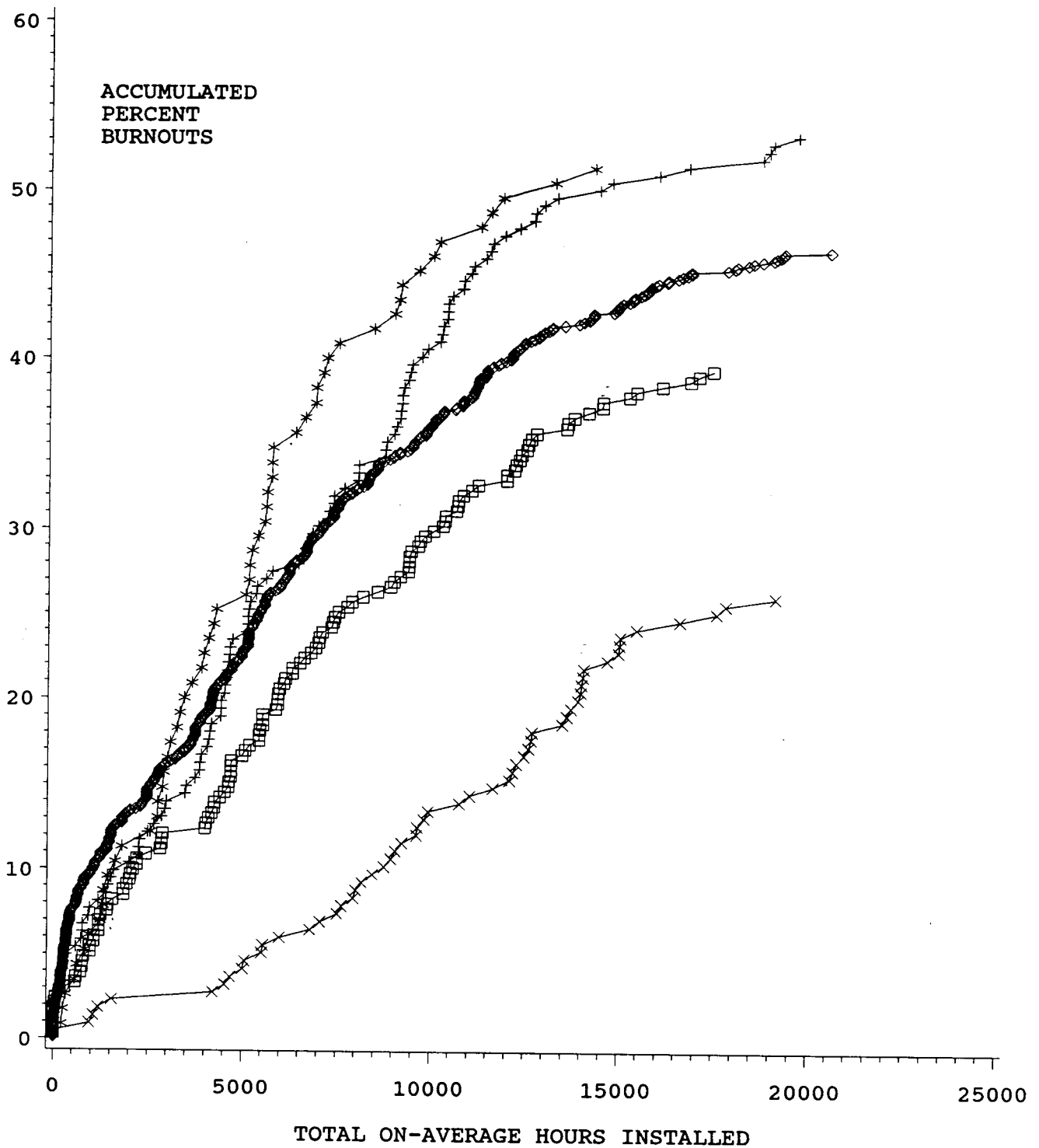
**FIGURE 24.**  
**BEST CASE BY MANUFACTURER.**  
**FOR TOTAL AVERAGE CYCLES TRAFFIC ONLY STANDARD 8" LAMPS TEST 1**  
**BY VOLTS, WATTS AND FILAMENT SUPPORTS**



**FIGURE 25.**  
**WORST CASE FOR KRYPTON WATT-SAVER 12"**  
**BEST CASE FOR OTHER LAMP TYPES**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED TEST 1**

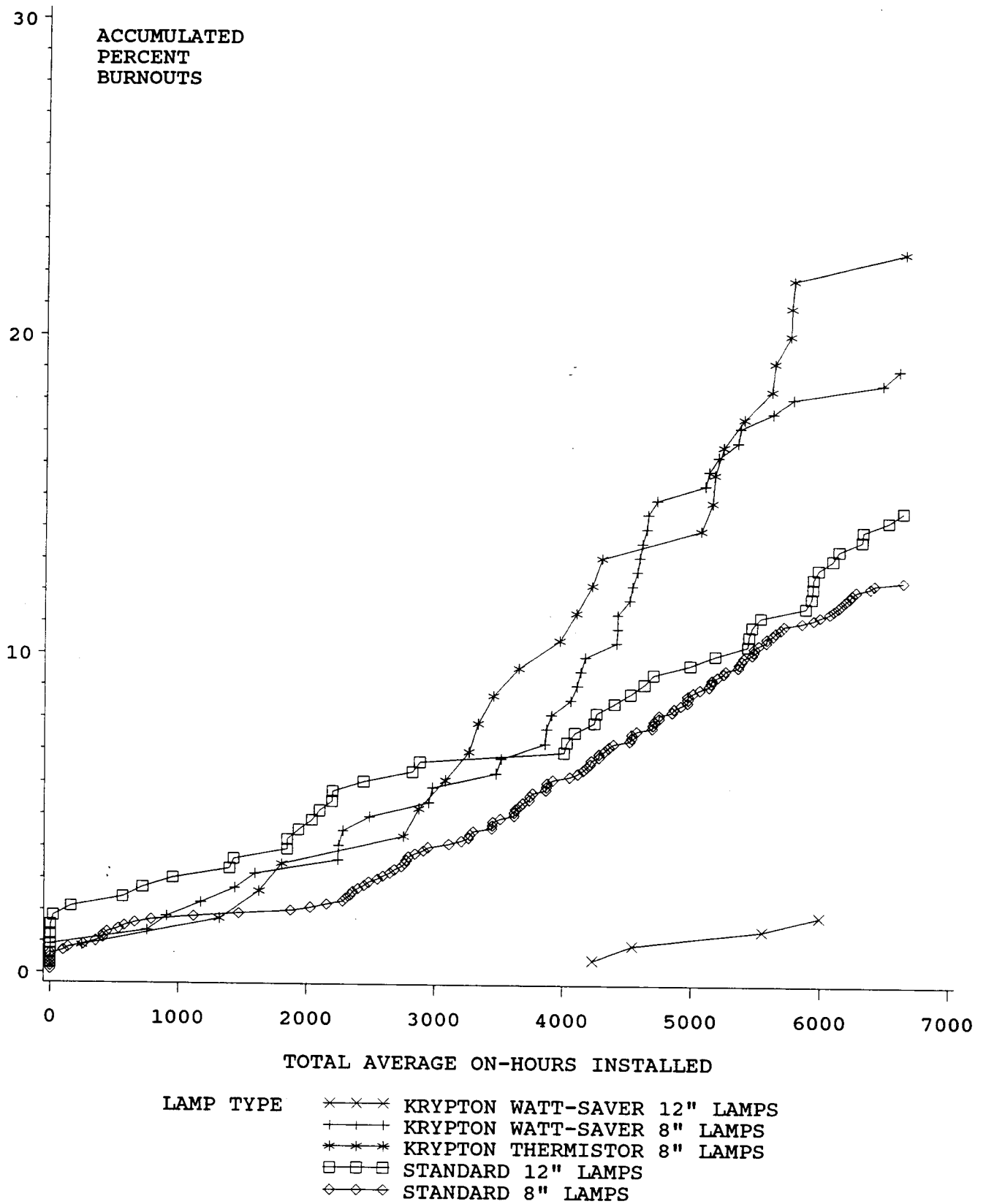


**FIGURE 26.**  
**WORST CASE BY LAMP TYPE**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED TEST 1**



LAMP TYPE	*-*-*	KRYPTON WATT-SAVER 12" LAMPS
	+ + +	KRYPTON WATT-SAVER 8" LAMPS
	* * *	KRYPTON THERMISTOR 8" LAMPS
	□ □ □	STANDARD 12" LAMPS
	◇ ◇ ◇	STANDARD 8" LAMPS

**FIGURE 27.**  
**BEST CASE BY LAMP TYPE 6000 HOURS**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED TEST 1**



**FIGURE 28.**  
**BEST CASE BY LAMP TYPE 8000 HOURS**  
**FOR TOTAL AVERAGE ON-HOURS INSTALLED TEST 1**

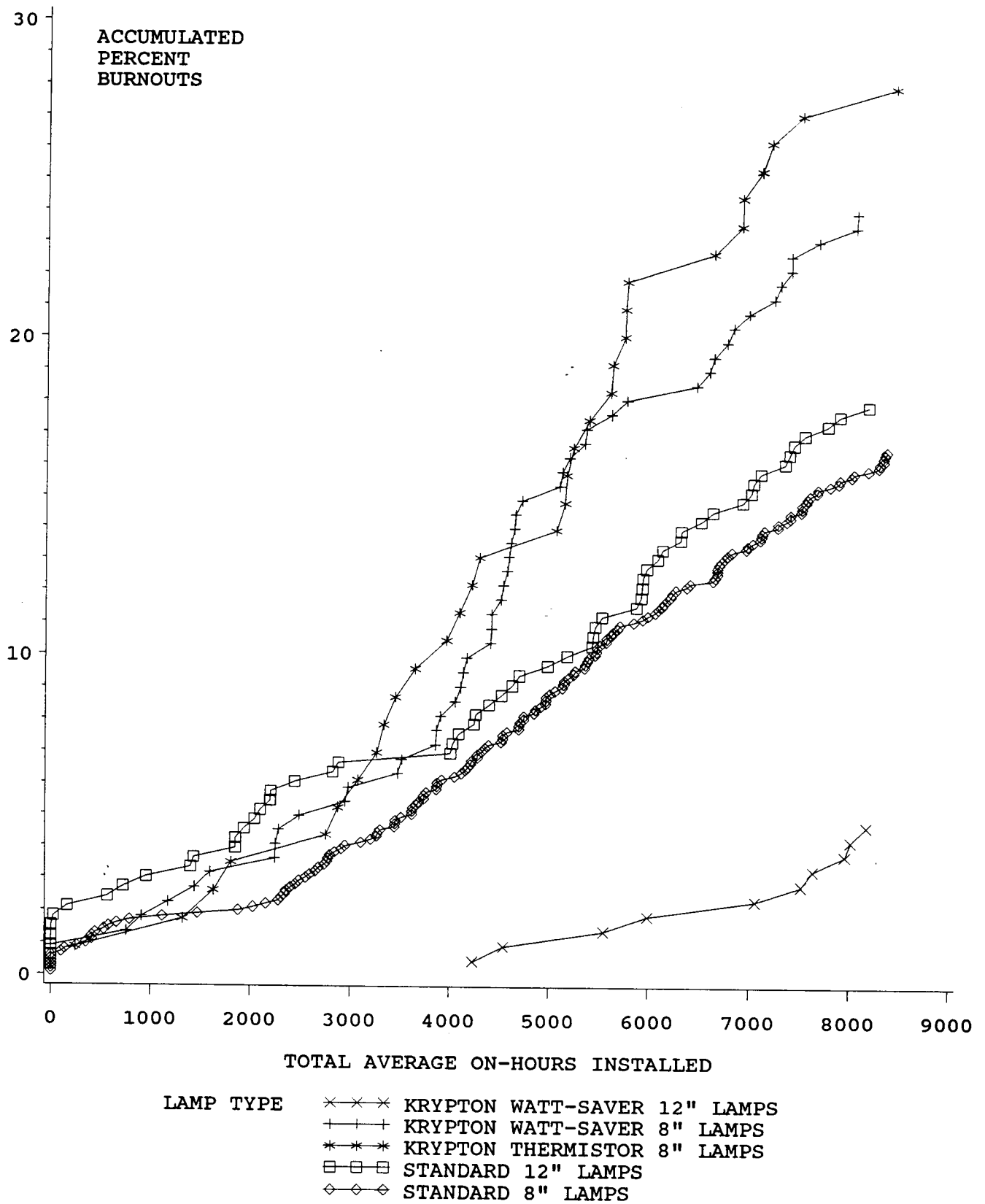


TABLE 1

OWNERSHIP COST FOR 1,000 LAMPS AT 6,000 ON-HOURS TEST 1  
 BASED ON \$50.00 MINIMUM PER CALL-OUT DUE TO A BURNOUT

COST PER LAMP IN DOLLARS	COST PER ONE THOUSAND LAMPS IN DOLLARS	KRYPTON THERMISTOR 8"LAMPS 21.7% BURNOUTS IN 5769 HOURS INSTALLED 217 BURNOUTS \$10,850	KRYPTON WATT-SAVER 12"LAMPS 1.9% BURNOUTS IN 5996 HOURS INSTALLED 19 BURNOUTS \$950	KRYPTON WATT-SAVER 8"LAMPS 18.0% BURNOUTS IN 5772 HOURS INSTALLED 180 BURNOUTS \$9,900	STANDARD 12" LAMPS 13.0% BURNOUTS IN 6085 HOURS INSTALLED 130 BURNOUTS \$6,500	STANDARD 8" LAMPS 11.3% BURNOUTS IN 6061 HOURS INSTALLED 113 BURNOUTS \$5,650
.20	200	11,050	1,150	10,100	6,700	5,850
.30	300	11,150	1,250	10,200	6,800	5,950
.40	400	11,250	1,350	10,300	6,900	6,050
.50	500	11,350	1,450	10,400	7,000	6,150
.60	600	11,450	1,550	10,500	7,100	6,250
.70	700	11,550	1,650	10,600	7,200	6,350
.80	800	11,650	1,750	10,700	7,300	6,450
.90	900	11,750	1,850	10,800	7,400	6,550
1.00	1,000	11,850	1,950	10,900	7,500	6,650
1.20	1,200	12,050	2,150	11,100	7,700	6,850
1.40	1,400	12,250	2,350	11,300	7,900	7,050
1.60	1,600	12,450	2,550	11,500	8,100	7,250
1.80	1,800	12,650	2,750	11,700	8,300	7,450
2.00	2,000	12,850	2,950	11,900	8,500	7,650
2.20	2,200	13,050	3,150	12,100	8,700	7,850
2.40	2,400	13,250	3,350	12,300	8,900	8,050
2.60	2,600	13,450	3,550	12,500	9,100	8,250
2.80	2,800	13,650	3,750	12,700	9,300	8,450
3.00	3,000	13,850	3,950	12,900	9,500	8,650
3.20	3,200	14,050	4,150	13,100	9,700	8,850
3.40	3,400	14,250	4,350	13,300	9,900	9,050
3.60	3,600	14,450	4,550	13,500	10,100	9,250
3.80	3,800	14,650	4,750	13,700	10,300	9,450
4.00	4,000	14,850	4,950	13,900	10,500	9,650
4.20	4,200	15,050	5,150	14,100	10,700	9,850
4.40	4,400	15,250	5,350	14,300	10,900	10,050
4.60	4,600	15,450	5,550	14,500	11,100	10,250
4.80	4,800	15,650	5,750	14,700	11,300	10,450
5.00	5,000	15,850	5,950	14,900	11,500	10,650

**FIGURE 29.**  
**OWNERSHIP COSTS AT 6000 ON-HOURS BY LAMP TYPE**  
**BASED ON \$50.00 PER CALL-OUT FOR TEST 1**

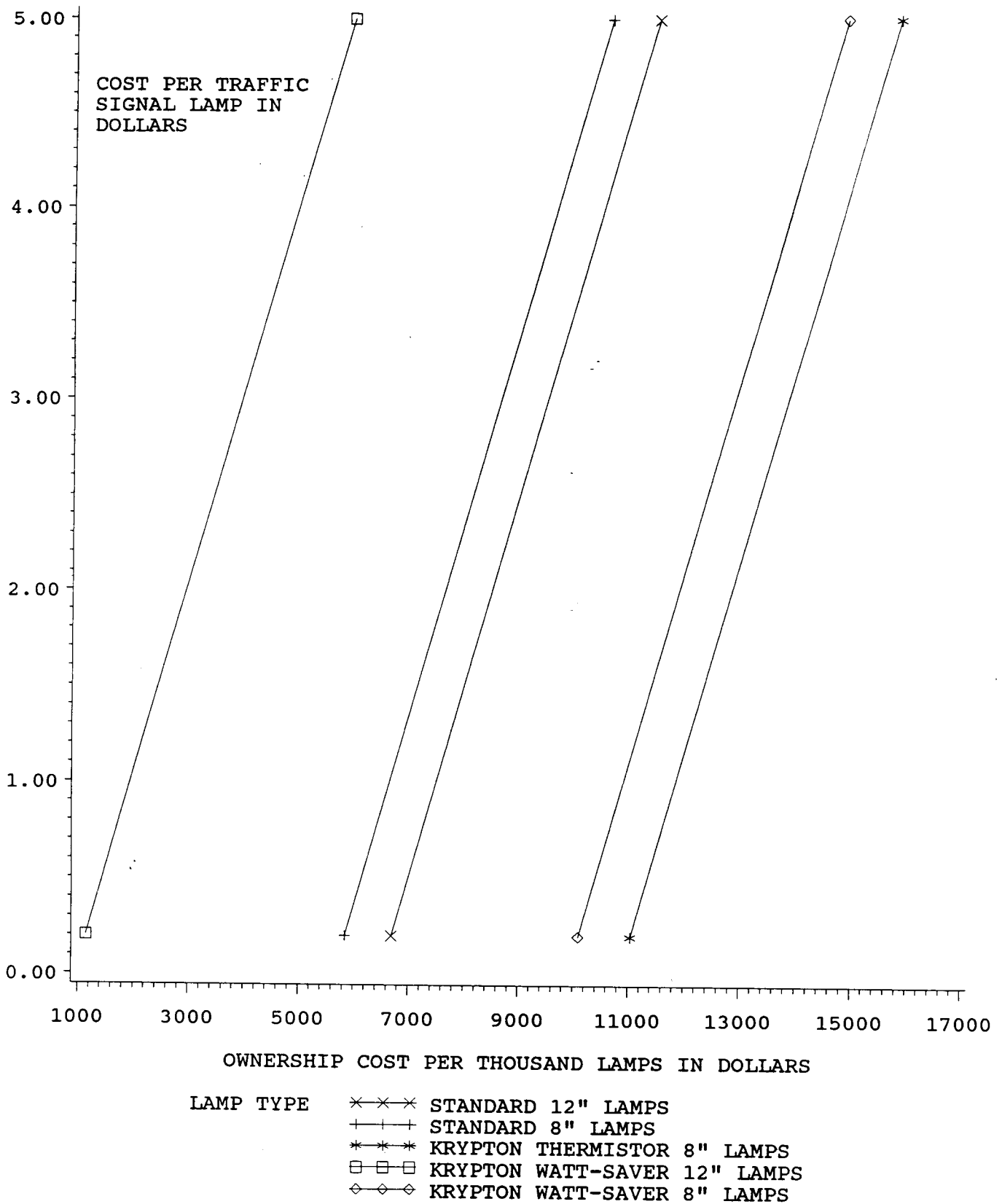
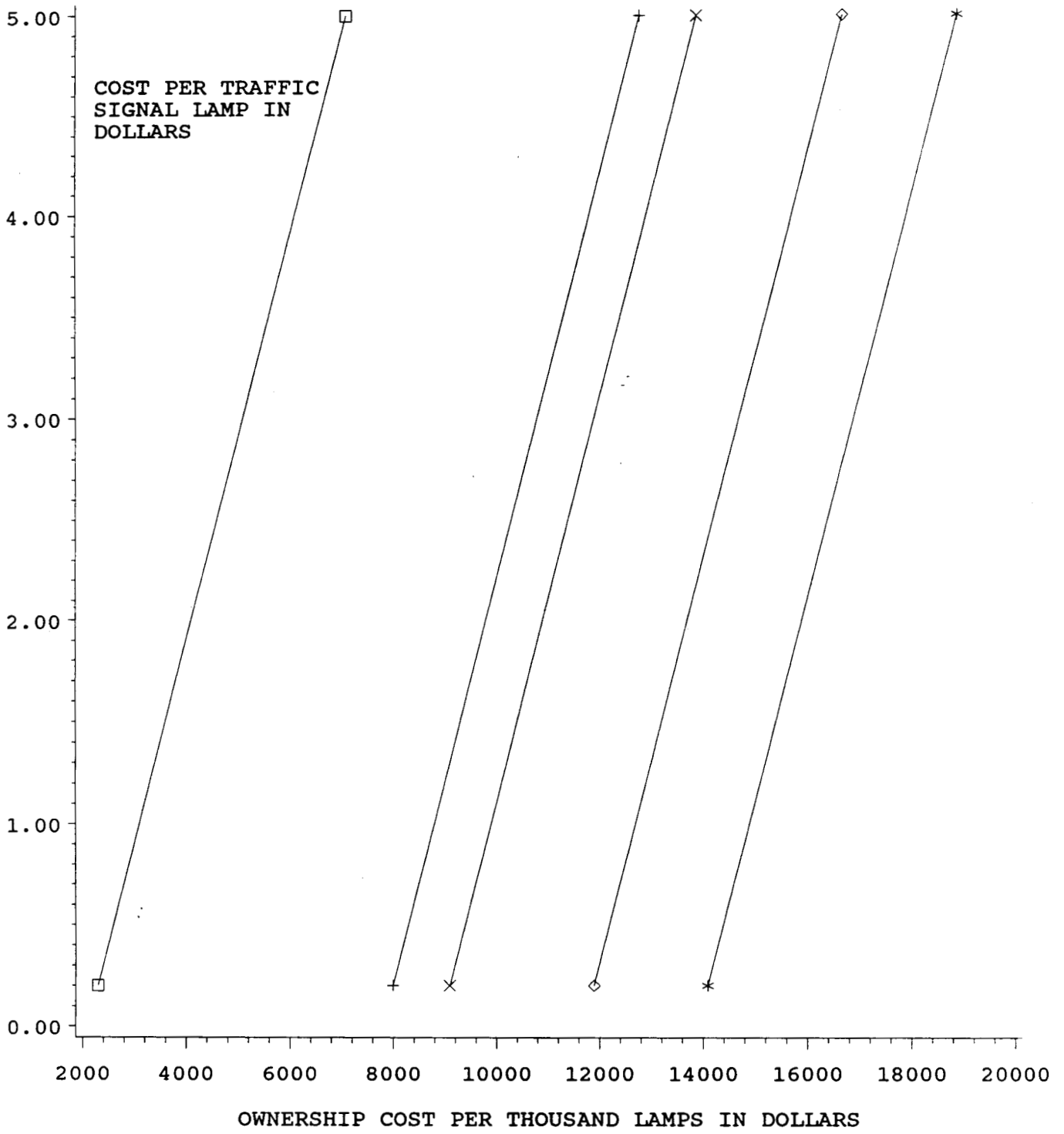


TABLE 2

OWNERSHIP COST FOR 1,000 LAMPS AT 8,000 ON-HOURS TEST 1  
 BASED ON \$50.00 MINIMUM PER CALL-OUT DUE TO A BURNOUT

COST PER LAMP IN DOLLARS	COST PER ONE THOUSAND LAMPS IN DOLLARS	KRYPTON THERMISTOR 8" LAMPS 27.8% BURNOUT IN 8450 HOURS INSTALLED 278 BURNOUTS \$13,900	KRYPTON WATT-SAVER 12" LAMPS 4.2% BURNOUTS IN 8018 HOURS INSTALLED 42 BURNOUTS \$2,100	KRYPTON WATT-SAVER 8" LAMPS 23.4% BURNOUTS IN 8051 HOURS INSTALLED 234 BURNOUTS \$11,700	STANDARD 12" LAMPS 17.8% BURNOUTS IN 8184 HOURS INSTALLED 178 BURNOUTS \$8,900	STANDARD 8" LAMPS 15.6% BURNOUTS IN 8015 HOURS INSTALLED 156 BURNOUTS \$7,800
.20	200	14,100	2,300	11,900	9,100	8,000
.30	300	14,200	2,400	12,000	9,200	8,100
.40	400	14,300	2,500	12,100	9,300	8,200
.50	500	14,400	2,600	12,200	9,400	8,300
.60	600	14,500	2,700	12,300	9,500	8,400
.70	700	14,600	2,800	12,400	9,600	8,500
.80	800	14,700	2,900	12,500	9,700	8,600
.90	900	14,800	3,000	12,600	9,800	8,700
1.00	1,000	14,900	3,100	12,700	9,900	8,800
1.20	1,200	15,100	3,300	12,900	10,100	9,000
1.40	1,400	15,300	3,500	13,100	10,300	9,200
1.60	1,600	15,500	3,700	13,300	10,500	9,400
1.80	1,800	15,700	3,900	13,500	10,700	9,600
2.00	2,000	15,900	4,100	13,700	10,900	9,800
2.20	2,200	16,100	4,300	13,900	11,100	10,000
2.40	2,400	16,300	4,500	14,100	11,300	10,200
2.60	2,600	16,500	4,700	14,300	11,500	10,400
2.80	2,800	16,700	4,900	14,500	11,700	10,600
3.00	3,000	16,900	5,100	14,700	11,900	10,800
3.20	3,200	17,100	5,300	14,900	12,100	11,000
3.40	3,400	17,300	5,500	15,100	12,300	11,200
3.60	3,600	17,500	5,700	15,300	12,500	11,400
3.80	3,800	17,700	5,900	15,500	12,700	11,600
4.00	4,000	17,900	6,100	15,700	12,900	11,800
4.20	4,200	18,100	6,300	15,900	13,100	12,000
4.40	4,400	18,300	6,500	16,100	13,300	12,200
4.60	4,600	18,500	6,700	16,300	13,500	12,400
4.80	4,800	18,700	6,900	16,500	13,700	12,600
5.00	5,000	18,900	7,100	16,700	13,900	12,800

**FIGURE 30.**  
**OWNERSHIP COSTS AT 8000 ON-HOURS BY LAMP TYPE**  
**BASED ON \$50.00 PER CALL-OUT FOR TEST 1**



**LAMP TYPE**    \*-\*-\* STANDARD 12" LAMPS  
 +--+ STANDARD 8" LAMPS  
 \*-\*- KRYPTON THERMISTOR 8" LAMPS  
 □-□- KRYPTON WATT-SAVER 12" LAMPS  
 ◇-◇- KRYPTON WATT-SAVER 8" LAMPS

APPENDIX 12  
IMPLEMENTATION PLAN

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## INTRODUCTION

The current bid specification for traffic signal lamps provides for purchasing the traffic signal lamps from the distributor or manufacturer that submits the lowest bid price. The bid winner can also be the distributor and/or manufacturer that gives the largest percentage discount from the distributors or manufacturer's catalog list prices for traffic signal lamps.

When the lowest price bid for traffic signal lamps is the criteria used to determine the bid winner, the Departments of Transportation and Treasury are assuming that the lowest priced traffic signal lamp is identical to all other bids from the lowest to the highest price. The presumption is that the only difference is price. Quality (installed lamp lifetime) is considered to be the same for all traffic signal lamps bid since all of the lamps have the same manufacturer rated life of 8,000 hours.

The results of this project shows (Figures 2, 8, 25, 26, 27, 28, 29, 30 and Tables 1 and 2) that neither the highest priced lamp type nor the lowest priced lamp types yielded the lowest number of burnouts for twelve-inch signal faces and hence the lowest ownership cost.

When the results for lamps for eight-inch signal faces are considered (Figures 2, 8, 14, 20, 25, 26, 27, 28, 29, 30 and Tables 1 and 2) the lowest priced lamp type has the least amount

of burnouts and the lowest ownership costs. However standard lamps from different manufacturers (Figure 8) had various APB and ownership cost. Standard lamps for eight-inch signal faces from the same manufacturers but from different production lots (Figure 20) shows different installed lamp lifetimes.

Lamp quality varies from manufacturer to manufacturer for the same lamp type and from the same manufacturer for the same lamp type at various times. This variation in quality is assumed to be the lack of automatic production line controls, automatic inspection of each lamp, and automatic rejection of individual defective lamps.

Manufacturing production line inspection by Department inspectors does not take place. Boxes of lamps from various production runs are delivered to the Department throughout the year. Even if a quantity of lamps is ordered for group relamping of a region, the lamps that are delivered will probably be from different production lots since the lamps are taken from the manufacturer's or distributor's warehouse.

When an electrical mechanic replaces a burned out lamp in a signal face, should the other lamps be replaced in the same and adjacent red and/or green signal faces or should only the burned out lamp be replaced? With a database of timing for each signal face at a signalized intersection in a microcomputer's data base the total average on-time for each lamp in the intersection can be printed out and given to the electrical mechanic as needed.

Replacing one lamp or three lamps does not take that much

more time in the same or adjacent signal heads since the same safety setup is used.

Presently the on-time is unknown. But if it were known, during a replacement of another burned out lamp, should an adjacent lamp with 6,000 total average on-hours be replaced with a new lamp that might burnout earlier than the present lamp? The installed lamp might last another 3,000 total average on-hours until group relamping. If an electrical mechanic had confidence in the quality of the lamps (installed lamp lifetime) then future callouts to those signal faces because of excessive on-time hours on the lamps behind red or green signal faces would be reduced. These lamps would have been replaced before burning out.

Considering the present practice as delineated above one can better understand the purpose for including some of the steps in the Implementation Plan.

## IMPLEMENTATION PLAN

The results of this project can be implemented by the following steps. These are:

- . Develop a lamp bid specification.
- . Establish a twelve to sixteen month group relamping in all of the Regions.
- . Determine the total average on-time for each lamp in each signal face assuming up to a sixteen month group relamping cycle. Use the on-time to determine the group relamping schedule.
- . Monitor lamps for reasons of removal.
- . Evaluate lamps for accumulated percent burnouts versus total average on-time.
- . Maintain a data base on ownership costs of lamps for every relamping cycle.
- . Determine ownership costs for each group relamping prior to issuance of the next request for bid. Apply this information to weigh the bid price and determine the bid winner.

The goal of the implementation plan would be to keep burnouts before group relamping to under four percent. This represents less than 2,400 burnouts per 60,000 lamps for the state maintained intersections.

To determine the requirements in a traffic signal lamp specification the following four pages was prepared to send to the manufacturers of traffic signal lamps. The results of this

inquiry was to be incorporated into a specification. After the specification was written based upon knowledge and the information supplied by the manufacturers, it was intended that it be sent back to the manufacturers for their comments. The specification will set a minimum quality level for all manufacturers that bid on traffic signal lamps.



IN REPLY PLEASE REFER TO

State of New Jersey  
DEPARTMENT OF TRANSPORTATION

1035 PARKWAY AVENUE  
CN 600  
TRENTON, NEW JERSEY 08625

THOMAS M. DOWNS  
COMMISSIONER

Attached List

Subject: Lamp Manufacturer Information Request List

Gentlemen:

The New Jersey Department of Transportation is currently developing a traffic signal lamp specification. The purpose of developing this new specification is to purchase traffic signal lamps with the lowest ownership cost. Other benefits of this specification will be to increase motorist safety by decreasing early burnouts before scheduled relampings and to increase lamp quality by establishing methods for lamp evaluation, testing and inspection.

The New Jersey Department of Transportation in cooperation with the United States Department of Transportation and the Federal Highway Administration has completed a study evaluating various types of traffic signal lamps and their associated ownership costs. The results of this study are being implemented in New Jersey's new lamp bid specification.

The following information is being requested and is essential in developing this new specification. We are interested in quality control points that a state inspector should look for at the plant prior to and during a production run of our lamps. Areas of interest are quality of the materials and quality of the workmanship used in the manufacturing process.

The New Jersey Department of Transportation is expecting to let a contract for a one year supply of traffic signal lamps. The total amount of lamps to be supplied would be in the range of sixty to eighty thousand lamps. Please supply us with an approximate number of days that an inspector would be required to be present in the plant to properly inspect this total amount of lamps.

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We are requesting that the attached information be supplied for all traffic signal lamps listed in your catalog that your company manufacturers along with additional information you wish to supply.

Note: Please do not supply any information which your company considers to be proprietary.

This request is being sent to all manufacturers listed on the attachment.

Items of Interest for Inspection for All Traffic  
Signal Lamps Listed in Your Catalog

1. Type of gas fill used.
2. Percent of fill gas by volume.
3. Purity of the fill gas used.
4. Filament wire composition before and after processing.
5. Diameter of filament wire and minimum and maximum tolerances.
6. Diameter of filament coil and minimum and maximum tolerances.
7. Process used to fabricate filament wire from time of receiving to installation in the lamp.
8. Filament support wire diameter.
9. Filament support material composition.
10. Fuse lead wire size and ampere rating.
11. Dimensions for glass shell and minimum and maximum tolerances.
12. Dimensions for brass base and minimum and maximum tolerances.
13. Type of solder and flux used (specification).
14. Application process to solder fuse and power leads to lamp base.
15. Type of base cement used (specification).
16. Bonding process used to cement the lamp base to glass shell.
17. Quality control process used in screening for defects in materials and workmanship for all traffic signal lamp types before, during and after a production run of lamps for the following items:
  - a. Glass Shell
  - b. Filament Wire
  - c. Brass Base
  - d. Fill Gas
  - e. Fuse Lead
  - f. Power Leads
  - g. Filament Supports
  - h. Reflector
  - i. Solder
  - j. Brass Base Cement

18. Evacuation and sealing process used including amount of vacuum needed to give the proper gas fill for all traffic signal lamp types.
19. Please supply test set-up, test procedure and information for accelerated life testing as per I.T.E. spec for traffic signal lamps (dated 1980) for all traffic signal lamp types.
20. Supply information detailing production line maintenance and operational procedures.
21. Provide all information pertaining to packaging, lot number, record keeping and coding practices.

## IMPLEMENTATION PROCESS

### 1. Develop a Lamp Bid Specification

- A. Request information from the lamp manufacturers on their processes.
- B. Send draft specification to manufacturers for comments
- C. Determine the credit that should be received for lamps that burnout before 1,000 total average on-hours.
- D. Set inspection criteria for NJDOT inspector at time of determination of bid winner for a production run of lamps based on manufacturer supplied information. Inspection criteria can be manufacturer and lamp type specific.
- E. Separate traffic signal lamp bid from general lamp purchases.

### 2. Purchase Lamps

- A. Purchase lamps up to three times a year.
- B. Accept only lots inspected by NJDOT Inspectors.
- C. Implement project results initially purchasing krypton watt-saver lamps for twelve-inch signal heads and standard lamps for eight-inch signal heads.
- D. Allow for purchase of newer type lamps and evaluation of same.

### 3. Receiving Lamps

- A. Record all manufacturers' lot numbers and verify that lamps received were inspected at the plant by a DOT inspector.
- B. Assign and record a NJDOT lot number to each box of lamps.
- C. Distribute lamps to all regions in the state in proper quantities to relamp all intersections.

### 4. Prepare the Timing Data Base Installation and Burnout Sheets

- A. Calculate average signal heads timings for all intersections and enter this data into a timing data base. (This timing data base can then be used to schedule intersection group relamping based upon predicted total average on-hours.)
- B. Draw "Intersection Installation Sheets" for all Department maintained intersections in the state using a desk top microcomputer, see Figure 12-1.
- C. Print lamp replacement sheets, and distribute to all regional maintenance forces. See Figure 12-2.

### 5. Group Relamp

- A. Relamp all intersections. Fill-out a copy of the installation sheet with lamp type, for eight-inch and twelve-inch signal heads, NJDOT lot number, and installation date. Place copy of installation sheet in controller cabinet. (Lamps are not numbered on the base. The only indication required on the installation

sheet with respect to lamps is the indication of what DOT lot number the lamps are taken from.)

- B. Return original installation sheet to the office where the information will be entered into a database.
- C. Upon knockdown, burnout, signal revision or vandalism fill out a lamp replacement sheet to explain the reason for removal, and date of removal. The sheet will be returned to the office and entered into the microcomputer data base. A new record will be added to the database to account for the new lamp installed in that intersection.
- D. A refinement can be made on group relamping when a quality lot of lamps is received. Consider installing up to 480 lamps in intersections close to regional maintenance yards between six to eight weeks before group relamping. This represents over one thousand total average on-hours for the red on the side road and green on the main road traffic signals. Monitor the burnouts and use the results to predict the next optimum time to begin group relamping.

INSTALLED BY: \_\_\_\_\_  
 CONTROL SECTION \_\_\_\_\_  
 DATE OF LATEST REVISION \_\_\_\_\_  
 RELAMP DATE \_\_\_\_\_

PHONE \_\_\_\_\_  
 MAIN ROUTE \_\_\_\_\_  
 SIDE STREET \_\_\_\_\_

8" SIGNAL HEADS 5-7  
 DOT LOT# \_\_\_\_\_  
 HEAD NUMBERS \_\_\_\_\_  
 LAMP MANUFACTURER \_\_\_\_\_  
 MANUF LOT# \_\_\_\_\_

12" SIGNAL HEADS 1-4  
 DOT LOT# \_\_\_\_\_  
 HEAD NUMBERS \_\_\_\_\_  
 LAMP MANUFACTURER \_\_\_\_\_  
 MANUF LOT# \_\_\_\_\_

DOT LOT# \_\_\_\_\_  
 HEAD NUMBER ↔ \_\_\_\_\_  
 LAMP MANUFACTURER \_\_\_\_\_  
 MANUF LOT# \_\_\_\_\_

DOT LOT# \_\_\_\_\_  
 HEAD NUMBERS \_\_\_\_\_  
 LAMP MANUFACTURER \_\_\_\_\_  
 MANUFACTURER LOT# \_\_\_\_\_

PROGRAMMED LAMPS

LAMP MANUFACTURE \_\_\_\_\_  
 LAMP TYPE \_\_\_\_\_  
 LOT # \_\_\_\_\_

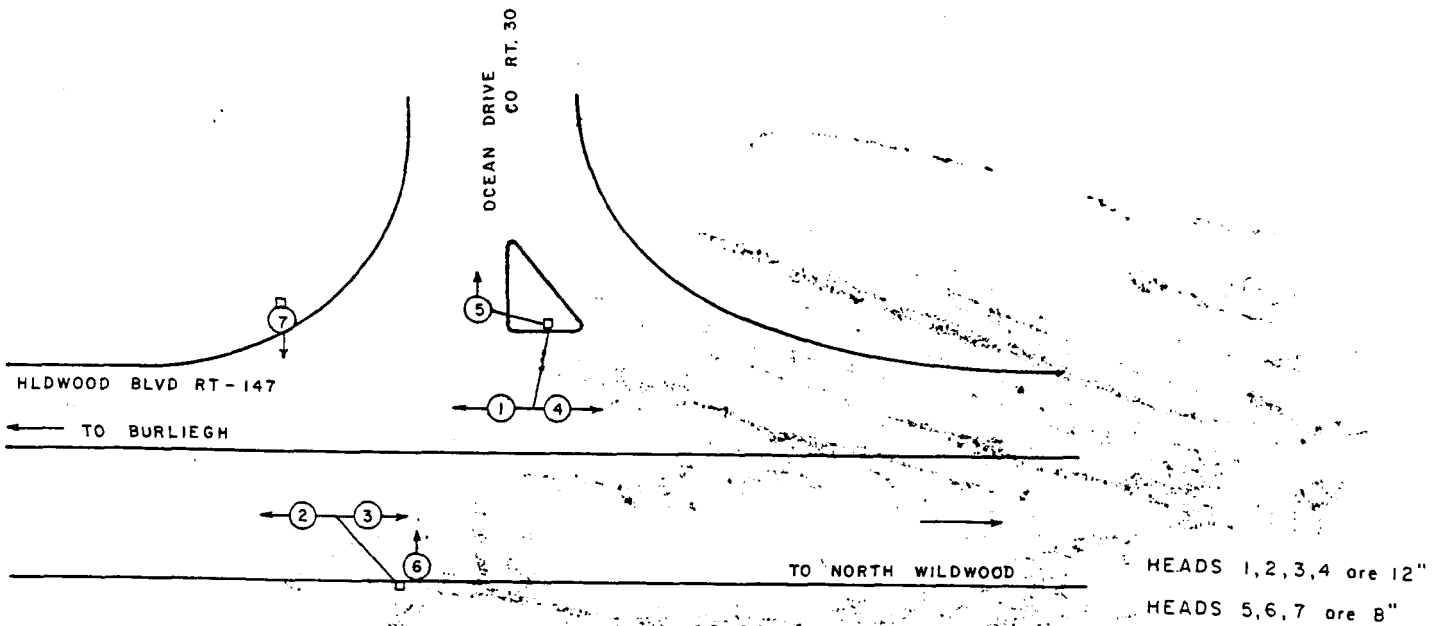
LAMP MANUFACTURE \_\_\_\_\_  
 LAMP TYPE \_\_\_\_\_  
 LOT# \_\_\_\_\_

p=programable lamps    ■ = 12" signal heads    blank = 8" signal heads

	1	2	3	4	5	6	7	8	9	10	11
RED	■	■	■	■							
YELLOW	■	■	■	■							
GREEN	■	■	■	■							

	12	13	14	15	16	17	18	19	20	21	22
RED											
YELLOW											
GREEN											



LAMP REPLACEMENT FORM

CONTROL SECTION # \_\_\_\_\_

REMOVE DATE \_\_\_\_/\_\_\_\_/\_\_\_\_

REASON FOR REPLACEMENT  
CHECK ONE

FOR KNOCKDOWN

BURNOUT \_\_\_\_\_  
KNOCKDOWN \_\_\_\_\_  
VANDELISM \_\_\_\_\_  
SIGNAL REVISION \_\_\_\_\_

LIST SIGNAL HEADS

\_\_\_\_\_

LAMPS INSTALLED

LAMP MANUFACTURER \_\_\_\_\_  
D.O.T. LOT# \_\_\_\_\_  
HEAD NUMBERS \_\_\_\_\_  
MANUFACTURER LOT# \_\_\_\_\_

LAMP MANUFACTURER \_\_\_\_\_  
D.O.T. LOT# \_\_\_\_\_  
HEAD NUMBERS \_\_\_\_\_  
MANUFACTURER LOT# \_\_\_\_\_

LAMP MANUFACTURER \_\_\_\_\_  
D.O.T. LOT# \_\_\_\_\_  
HEAD NUMBERS \_\_\_\_\_  
MANUFACTURER LOT# \_\_\_\_\_

LAMP MANUFACTURER \_\_\_\_\_  
D.O.T. LOT# \_\_\_\_\_  
HEAD NUMBERS \_\_\_\_\_  
MANUFACTURER LOT# \_\_\_\_\_

FILL IN HEAD NUMBER AND COLOR BELOW FOR SIGNAL REVISION,  
BURNOUT AND VANDELISM.

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R												
Y												
G												

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RETURN BURNED OUT LAMPS TO DESIGNATED INDIVIDUAL IN REGION  
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