FINAL REPORT

1985 ALASKA FIELD SURVEY OF PART-LOADING OF DIESEL-ELECTRIC GENERATORS

by

Ronald Johnson, Ph.D., P.E., Professor
and
John Gray, Research Assistant

Engineering Research Center
Institute of Northern Engineering
University of Alaska-Fairbanks
Fairbanks, Alaska 99775-1760

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STATE OF ALASKA
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RESEARCH SECTION
2301 Peger Road
Fairbanks, Alaska 99701

ABSTRACT

By conducting a survey by mail, by phone and in person, we obtained information on 356 diesel electric generator sets in Alaska in 1985. User groups surveyed included the Alaska Village Electric Cooperative (AVEC), public school districts, those certified by the Alaska Public Utilities Commission, the Tanana Chiefs, and the Alaska Department of Transportation and Public Facilities. Our survey focused on part-load operation.

We found that a lack of detailed site-specific data precludes making a general quantitative statement about part loading. The most detailed data, by far, are those collected by AVEC. Those data plus other information indicate that many gensets (some for good reasons) are underloaded, especially in the summer. The simple algebraic average July and January loadings for the 44 AVEC systems surveyed are close to 35% and 50%, respectively. Minimum loads as low as 15% occurred in the summer. AVEC recognizes the potential for improvement and has increased its system-wide efficiency by 25% from 1980 to 1985.

ACKNOWLEDGMENTS

We would like to gratefully acknowledge all the help provided by the users and operators that we contacted. We would especially like to thank Lloyd Hodson, General Manager of the Alaska Village Electric Cooperative, for the detailed data provided by AVEC.

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INTRODUCTION

The Diesel Electric Generator (DEG) Part-Load Field Survey was conducted in two complimentary phases from late May through August 1985. A survey form (see Appendix A) was adapted from one used in the previous summer's preliminary work on part-load efficiency of diesel engines. This survey was then distributed to all known operators of DEG sets in the 50 kW to 600 kW range in Alaska (see Appendix B for mailing list). Information on 356 generators was received. Personal interviews were the second source of data for the part-load study. Conducted either by phone or in person, this information illuminated the human, political and logistical problems that can prove to be more significant than the generator loading. For example, operating a diesel at a 90% load level will not insure a long, efficient engine life if the operator allows his diesel engine to run out of oil while he is away hunting.

In order to cover the greatest possible number of DEG installations, several different address sources were investigated. Schools in the remote villages often have their own generator sets (gensets). A mailing list of all public school districts was obtained (Mailing List No. 1 in Appendix B). All genset operators certified by the Alaska Public Utilities Commission (APUC) were mailed survey forms (Mailing List No. 2 in Appendix B). The Alaska Department of Transportation and Public Facilities (DOT&PF) operates remote highway maintenance camps throughout Alaska's road system. Many of these installations are powered by at least two gensets. Building Maintenance Manager for the Northern Region, Fred Barrett, provided a listing of maintenance camps within his region, and a method of distributing survey forms due to the inaccessibility of these camps through the U.S. mail system (Mailing List No.3 in Appendix B). The Tanana Chiefs Conference Inc. maintains an office which oversees operation of the 35 independent diesel-electric power plants in this corporation's villages. Jeff Weltzin, in the corporation's Energy Office, offered his assistance. The remaining 11 Alaska Native corporations were queried by mail to see if they maintained similar offices. No affirmative responses were received. Other potential information sources, uncovered during interviews, were grouped under the miscellaneous heading (Mailing List No. 4 in Appendix B).

WRITTEN SURVEY

Fifty-three Alaskan school districts were mailed survey questionnaires. Of the 15 replies received, nine districts were purchasing power from utilities, although three of these maintained gensets for emergency backup power. The Southeast Island School District purchases power where possible and uses diesel-electric generators (DEG) for prime power in five locations. Four of the remaining five school districts generate their own power. Finally, one school district answered our survey by saying they would not provide information because they felt research is a waste of time. Three of the four school districts returning useful replies had more than one installation. In all, 36 gensets were covered.

School districts, except the Kenai Peninsula School District, supplied manufacturer's information on their gensets. Pertinent data included 20 estimates, two hard numbers for genset loading, and two hard numbers for genset efficiency (kWh/gal). A complete listing of these data is found in Appendix C.

Michael Rohn, maintenance and facilities director at the Bering Straights School District, reported on 11 gensets. He believed the most urgent priority in DE power generation is the need for properly trained operators.

The APUC maintains a listing of all certificated commercial power producers which totals 55 companies. Two of these were eliminated immediately due to their large size, leaving 53 appropriate genset operators. Some, like the Tlingit and Haida Regional Electric Cooperative (one cooperative) with four power plants, own several individual installations. Others, like Robert Blodgett of the Teller Power Company, provide power from one small plant.

Twenty sites, owned by 15 production companies that answered the survey forms, operate 68 gensets. All plant operators were able to provide genset size, and engine and generator manufacturer. Average load figures on a yearly basis were provided for 12 gensets. Twenty-four genset average load figures on a summer/winter basis were also supplied. Fuel efficiency data were supplied for only six gensets. All figures are averages. No instantaneous high or low figures are available. A complete listing of the data is contained in Appendix D.

The Alaska Department of Transportation and Public Facilities (DOT&PF) is divided into three subregions: the northern region which includes Fairbanks, the central region which includes Anchorage, and the southeastern region which includes Juneau. The northern region contains 19 highway maintenance camps utilizing gensets. Among the 34 total gensets, four serve as standby units. The central region has only one installation remote enough to require DE power. This facility at Colson Bay uses two gensets; the remaining central region installations are tied to large utility grids or hydropower exclusively.

In similar fashion to those returned survey forms already covered, all locations supplied the manufacturer's names of their diesel engines. Seventeen of 28 installations (60.7%) reported yearly or seasonal average load level estimates, seven (21.95%) gave fuel consumption figures. No instantaneous or part-load levels of fuel consumption figures are available. The complete listing of data received is contained in Appendix E.

The remainder of the survey, the miscellaneous file, includes written responses from villages within the Tanana Chiefs Conference plus one verbal response from a private operator. Genset sizes were available from all replies, along with average figures for loading, and fuel consumption rates or total amounts used depending on response. No instantaneous load levels or fuel consumption figures are available. A complete listing of results is contained in Appendix F.

The summer 1985 survey on the part-loading of DEG returned no detailed quantitative low-load information except for the AVEC villages discussed later. Positive results were the generation of a data base providing genset size, location and general operation parameters such as total or average fuel use, and average load levels. This could serve as a starting point for a more detailed data acquisition effort.

PERSONAL INTERVIEWS

The second major avenue for data acquisition was personal interviews. DOT&PF was contacted numerous times in the course of building our data base. We discussed DEG power production problems with the Alaska Power Authority (APA). The Tanana Chiefs Conference provided addresses of gensets operated by villages within this Native corporation as well as information on the State Power Cost Equalization Program, or PCE. The Alaska Village Electric Cooperative (AVEC) released an extensive amount of genset load level data.

The Alaska Power Authority promotes energy-saving measures in power plants across Alaska (as demonstrated in their Waste Heat Study that is examined later) as well as administering the PCE program. Jerry Larson and Peter Hanson of APA discussed a variety of topics relating to DEG operation and economics. Problems emphasized with power plant operation were: (1) the nearly universal oversizing of gensets with respect to load (more than 90% of all installations in Alaska) according to Peter Hanson; (2) failure to utilize electric, thermostatically controlled fans to minimize cooling system horsepower drag; and (3) failure to maintain sufficiently high combustion chamber temperatures. The need to attract more qualified personnel to operate gensets was also mentioned. Operators with experience are discouraged from taking such positions due to low wages. Larson and Hanson both see privately owned gensets as the cleanest operations due to the owner-operator's desire to protect his investment. High fuel costs are the largest single component of genset operating expenses. Correct genset sizing is very important. A DEG sized for a projected maximum loading five years hence would operate inefficiently for several years before it could be considered optimized. In many cases, it is reasonable to expect that this period of time prior to optimization may be most of the useful life of the engine.

On the subject of power quality, both engineers recommended that electronic governors be used exclusively over the older hydromechanical units. The electronic governors such as a Woodward 2301 are capable of maintaining a plus/minus 1% frequency control which is a significant improvement over the plus/minus 5% frequency fluctuation experienced with older hydromechanical units such as the Woodward PSG. This improved frequency accuracy is necessary due to the increasing use of sophisticated electronic hardware such as television sets and personal computers. This issue of power quality is the subject of a separate study currently under way.

Jeff Weltzin, at the Energy Office of the Tanana Chiefs Conference, summarized the use of DEGs within his jurisdiction. Of these 43 villages, eight are supplied power from AVEC facilities. The remaining 35 are powered by independent producers. Weltzin also singled out the oversizing of gensets as being a major problem. Given as an example was Chalkytsik where the average power use is 35 kW, and the gensets are sized at 85 kW and 125 kW. Historical power use and short-term future needs are the two most significant considerations when sizing gensets.

ALASKA VILLAGE ELECTRIC COOPERATIVE

The Alaska Village Electric Cooperative (AVEC) provides electrical power to 48 Alaskan villages from 45 DEG plants with the assistance of two small interties. Lloyd Hodson, General Manager, and Mark Teitzel, Engineering Manager, explained AVEC operations and present in-house research during two interview sessions. The most detailed genset loading data presently available in Alaska were then released by AVEC for examination. Because AVEC records form the best available data base, they are useful in energy use calculations.

The typical AVEC power plant design has two larger units, each capable of carrying the entire load and one unit for use during summer months. Caterpillar diesel engines used to be the prime mover of choice, but recent AVEC testing has shown Cummins (model KITA 1150, 1,200 rpm, 250 kW @ 15 kWh/gal) to be the most efficient engine. Recently, a newly introduced Cummins L-Series (1,800 rpm) achieved greater than 15 kWh/gal. AVEC is now generally installing Cummins where replacement is necessary. Of course, AVEC will consider other suppliers as their efficiencies improve. Consideration of the economics and useful engine life remaining has slowed the changeover to the more fuel efficient engines. According to Hodson, about half of the AVEC system power plants could be considered reasonably well optimized at current loads, and the overall electrical generation efficiency ranged from 9 kWh/gal in the summer to as high as 14 kWh/gal in the winter in 1985.

AVEC has improved fuel efficiency by 25% over the past five years by system improvements based on analysis of the data. Recent information indicates a 5% gain from 1984 to 1985 with a system efficiency of 10.2 kWh/gal (25%) in 1985. Hodson also expects a yearly average from 11 to 11.5 kWh/gal (27.2% to 28.4% energy conversion efficiency) when the two-year optimization plan can be completed. This requires substantial amounts of additional REA loan money or state grants which are becoming increasingly difficult to obtain. The main limiting factors on even higher efficiencies are a lack of continual presence of an operator and poor load profiles in the summer and late at night.

In most cases, due to isolated and often unmanned operation, the genset must be bigger since it supplies all swing power. Typically, the daily 15-minute peaks range up to 2.5 times the average load with instantaneous peaks up to 15% higher still.

Fuel efficiency testing is carried out at AVEC's facility in Anchorage. Gensets are connected to variable resistive loads, and fuel flow is measured by weighing the fuel used over a certain time. Results are presented as fuel consumed (or kWh/gal plotted) vs load in kW. The fuel consumption curve has an ordinate intercept relating to parasitic frictional horsepower of the oil pump and water pump, and the sliding friction of mechanical parts. Because of this, low-load operation is intrinsically inefficient. Over most of the genset's operating range, the fuel consumption curve has a constant slope with a slight increase because of an apparent overfueling at peak loads. Some soot in the exhaust is noticed at this point. Attempts to minimize fixed losses are apparent in the move by some manufacturers from conventional V-belts to flat belts. This parallels the move by automobile manufacturers from the older belt to the newer "flat belt." The flat belt actually has an equivalent friction area spread over four to five small tandem vees, thus decreasing the frictional losses associated with greater flexing required by deep vee configuration. Other efforts center on reducing water and oil pumping losses and improving piston ring designs.

A summary of some of the data available from AVEC is presented in Appendix G. Columns 2 to 4 provide information on the diesel engine and electric generator of each site. The diesel models whose identification numbers begin with D such as D342 and D353 plus the 3304 and 3400 series are manufactured by Caterpillar. The 4-71 and 6-71 series are produced by Detroit Diesel, the 6619A series by John Deere, and the 685I, 2100V, and 3500 by Allis Chalmers. The next six columns correspond to load levels and efficiencies, and the last column is devoted to comments. The fuel use figures are converted to efficiencies by assuming a heating value of 138,616 Btu/gal for the diesel fuel.

To see how these values in Appendix G were obtained, consider the detailed original data for Ambler presented in Appendix H. These data are representative of those from each AVEC village. As explained by AVEC Data Analyst Berger Froiland, the data acquisition process starts with a form filled out by the village genset operator. In a few instances, gaps in the final curves are due to operators failing to complete the Plant Operator Log. Each power plant is checked three times daily for 21 readings per week. Weekly logs are then mailed to AVEC where the data are synthesized. Incentives are awarded to an installation if it has consistently operated the plant using the smallest genset capable of carrying the load. All quantities to be plotted are determined for the present week. Also compiled is a ledger of monthly kWh produced, kWh sold, efficiency, and individual engine operating hours and oil consumption.

The following is an explanation of the significant data from the Ambler Plant Operator Log (Appendix H1).

TIME OF DAY (Column 2): Readings taken at three to four random, yet relatively consistent day-to-day, times per day.

TOTAL ENGINE HOURS (Column 6): These data taken from the genset instrument panel.

TOTAL KWH GENERATED (Btwn. Columns 20-21): Reading taken from kWh meter on genset.

STATION FREQUENCY (Column 23): Reading taken from instrument panel, before adjustment. This reading reflects power requirements.

INSTANTANEOUS KW (Column 28): Reading taken from genset instrumentation. This reflects instantaneous loading.

GALLONS PUMPED INTO DAY TANK AT EACH FILLING (Column 30):
This reading is the best representation of daily fuel use.

The Ambler Generator Plant Yearly Status Plot (Appendix H2) contains the following information (obtained from Plant Operator Log):

KW LOAD LEVELS (Left Plot): These figures are the maximum, minimum and (mathematical) average loads, taken from operating logs. Actual maximum and minimum loadings are, in probability, not recorded since readings are only taken three times daily.

KWH/GAL (Middle Plot): This figure is calculated from monthly kWh meter readings and fuel consumptions for a given month.

FUEL CONSUMED (Right Plot): Weekly (Bottom) - this is a direct plot of total gallons of diesel fuel used during the respective week.
Monthly (Top) - this is a summation of all weekly fuel consumption figures in the respective month, plus the amount used during any fractional weeks during that month.

Part-loading levels of DEGs can be estimated from the AVEC raw data. As an example, consider the following data from Ambler (Appendix H).

Location, Year: Ambler, 1984

Low Load Data: 1 wk in Jun, 3 wks in Jul, 1 wk in Aug
48 kW for the above weeks

Gensets Operational:

Unit No.	Rating (kW)	Time Running (%) Jun	Jul	Aug
1	155	22.3	1.3	31.1
2	100	76.7	98.7	68.9

Calculation:

$$\frac{\text{load applied}}{\text{genset capacity}} \times 100\% = \%\text{ load}$$

Genset No. 1:

$$\frac{48\text{ kW}}{155\text{ kW}} \times 100\% = 31.0\%\text{ load}$$

Genset No. 2:

$$\frac{48\text{ kW}}{100\text{ kW}} \times 100\% = 48.0\%\text{ load}$$

Hence, estimated low loads correspond to 31% and 48% loading on the 155 kW and 100 kW gensets, respectively. The latter appears in the fifth column of Appendix G and is consistent with the assumption that the smallest genset capable of carrying the load is used. However, from the raw data, we can't be certain that the smallest genset was actually operating during the time of minimum recorded load. The average yearly fuel usages and maximum monthly usages are taken directly from AVEC-supplied data.

The third part of Appendix H (H3) summarizes the Ambler (and other village) data on a monthly basis. These data were used to get the kWh/gal data and efficiencies appearing in Appendix G.

The following is a sample calculation of fuel consumption and energy efficiency at the highest fuel consumption. These figures were taken for Ambler from the AVEC ledger.

Average Fuel Consumption:

$$\frac{\text{Total kWh produced}}{\text{Total gal used}} = \frac{586{,}080 \text{ kWh}}{60{,}161 \text{ gal}} = 9.7 \frac{\text{kWh}}{\text{gal}}$$

Highest Fuel Consumption (per kWh produced): for June

$$\frac{\text{Monthly kWh produced}}{\text{Monthly gal used}} = \frac{32{,}400 \text{ kWh}}{3{,}689 \text{ gal}} = 8.8 \frac{\text{kWh}}{\text{gal}}$$

Energy Efficiency at Highest Fuel Consumption: for June

$$8.8 \frac{\text{kWh}}{\text{gal}} \text{ X } \frac{3{,}413 \text{ Btu/kWh}}{138{,}616 \text{ Btu/gal}} \text{ X } 100\% = 21.8\%$$

NOTE: These figures were taken from the AVEC ledger, and then calculations were made (as shown above) for illustrative purposes. When compared with similar hand calculations made on the AVEC ledger, there is frequently a 0.1 kWh/gal difference between AVEC data and data calculated in our fashion.

$$\text{Average difference} = \frac{0.1 \text{ kWh/gal}}{10 \text{ kWh/gal}} \text{ X } (100\%) = 1.0\%$$

The last series of bar graphs (Appendix I) summarizes the 44 AVEC installations that serve 48 villages across Alaska. All locations are powered by either two, three, or four diesel-electric generators, always run individually. All plots are based on data obtained from AVEC in 1985.

INSTALLED CAPACITY: This plot presents the number of individual gensets available for power production by segregated by rated capacity.

PEAK DEMAND: This plot displays the occurrence of given peak demand levels. The peak demands range from <50 kW to >300 kW, grouped in 50 kW increments. Occurrence is tabulated by the number of villages experiencing a given loading.

POWER GENERATION: The total numbers of GWh produced in 1985 are displayed by the installed capacity of the power plant. The following terms used in the plot are defined. TOTAL power is the number of GWh produced by the gensets. NET power is the total power less that used by the genset shed (e.g., lights, fuel pumps, vent fans). Since AVEC does not use radiator-mounted load banks, this "loss" is not included in net power. Power SOLD is ideally the net power minus line losses, but actually includes any power metering or power meter reading errors.

GENSET LOADING: Compiled from the load level plots, the maximum, minimum and average (not weighted) percent load for all 44 power plants are displayed for each month of operation. Here maximum loading is calculated by looking at the highest loading for each of the 44 plots and picking the maximum in a given month. Similarly, the minimum represents the smallest of the 44, and the average is for all 44 data points for each month.

LOAD LEVEL: These 44 plots describe the average relative loading (percent basis) at each of AVEC's power plants each month. Average loading was determined by dividing kWh produced during a given month by the rating of the genset in use. During months when more than one genset was used, the smallest genset rating capable of carrying the load was selected.

CONCLUSIONS

The overall collection of data assembled here confirms our hypothesis that many gensets in rural Alaska are underloaded at least during significant portions of the year. But a lack of detailed and comprehensive site-specific data precludes making a general quantitative, statistical statement about part-loading at this time. Such data would have to be obtained by instrumenting individual systems with watt meters and dataloggers. This should be done at several different sites as a follow-up to this study.

The most complete set of data available to us is that generated by AVEC and presented in Appendices G through I. The summary bar graph of genset loading vs month in Appendix I clearly shows that minimum loads are as low as 15% in the summer and 25% in the winter. Of course, by definition, all plants but one experience loads higher than these minimum values appearing on the summary plot. The simple algebraic average July loading is closer to 35% and the average January loading is almost 50%.

The school districts (Appendix C) reported average summer loads ranging from 25% to 35%, the APUC villages (Appendix D) from 30% to 75%, and the DOT&PF maintenance camps from 25% to 75%. These data, however, must be considered less certain than data supplied by AVEC.

According to Malosh, Johnson and Bubendorf (1986), Alaskans knowledgeable about DEG recommend minimum loads between 30% and 50% of rated capacity. By this standard, most plants fall in a safe range during the winter, but many do not during the summer. The AVEC data, when taken collectively with the remaining (less comprehensive) data, indicate that many gensets in Alaska are underloaded. As detailed earlier in this report and in Malosh et al. (1986), there are many reasons for operating at low loads, some of which are justified. Moreover, it is not economically prudent to replace an oversized genset just because it is sometimes underloaded. Some of the possible solutions to operational problems caused by underloading are discussed in Malosh et al. (1986). The purpose of this survey is not to discuss cures but rather to better quantify the current situation in Alaska.

Operating at part-loads not only can cause long-term maintenance problems but can also reduce fuel economy. For example, the average fuel use for the 44 AVEC power production systems surveyed (Appendix G) ranged from 7.0 to 12.1 kWh/gal, with a simple algebraic average of 9.4 in 1984. The maximum monthly fuel usage rates during the low load periods ranged from 5.9 to 11.0 kWh/gal, with a simple algebraic average of 8.1. The latter corresponds to an efficiency of 20%, assuming an energy content of 138,616 Btu/gal for the diesel fuel. Of course, this arithmetic average doesn't properly reflect the higher efficiencies associated with the larger generator sets. When the individual efficiencies are weighted by kWh produced, the AVEC system-wide efficiency was 9.7 kWh/gal in 1984 and 10.2 in 1985.

IMPLEMENTATION STATEMENT

This report describes one more step in our continuing effort to identify the true cost to the State of electric power production using small, noninterconnected diesel-electric systems. The theory behind this investigation is this: The conventional methods used when analyzing power costs in rural areas are over simplistic. Our research to date suggests that the true cost to the user (primarily the State, but also the individual) may be much higher than anticipated when the direct and indirect effects of the following factors are considered:

* Part-Load performance
* Power outages and power signal quality
* Maintenance

When comprehensive data on the economic effects of all of these factors is assembled we anticipate that practical ways toward reducing power costs, while simultainously improving performance and reliabity, will become evident. We also suspect that it will be possible to do this with existing technology. The potential for savings is great. Considering the subject of this report alone, a one percent increase in the overall conversion efficiency of diesel-electric systems resulting from treating the part-load problem, could save consumers over one million dollars per year statewide. And that is a savings of only about one half cent per kiloWatt hour.

This is but one piece in a complex puzzle. Exactly what savings are attainable, how they might be attained, and at what cost will only be clear once a complete data base has been developed and carefully analyzed. This has never been done before for these types of systems, although it is routine in the utility industry for larger systems.

At this point no direct implementation of research results is recommended. We will continue to gather and analyze data while performing small field experiments. We expect at least one year further will be required before specific implementation schemes could be formulated.

L. E. Leonard, P.E.
Facilities Research Manager

REFERENCES

Malosh, J., R. Johnson, and S. Bubendorf. 1985. Part-load economy of diesel-electric generators. Alaska Department of Transportation and Public Facilities. Report No. AK-RD-86-01.

APPENDIX A

SAMPLE SURVEY FORM

Diesel-Electric Generator Survey

1. How many diesel-electric generator sets are on site? ________

2. Who is(are) the diesel engine manufacturer(s)? ________________
____

3. Who is(are) the generator manufacturer(s) and what size is(are) the unit(s)? ______________________ ______ KW
______________________ ______ KW

4. Does the primary generator set run continuously? ____________

5. Estimate the generator loading (e.g. 25%, 50%, 75% ...), and fuel consumption (gallons consumed).

		LOADING	FUEL USE
Gen.	April - September	________ %	________ gals.
No.1	October - March	________ %	________ gals.
Gen.	April - September	________ %	________ gals.
No.2	October - March	________ %	________ gals.

Note: If there are more than two generators, include loading and fuel use information under question No.9.

6. If dummy loads, load banks, or other artificial loading is used, estimate the percent of system capacity (e.g. 25%, 50%, 75% ...) dedicated to the additional load.

	April - September	October - March
LOADING:	________%	________%

7. If the generator is NOT being run at full load continuously:

   a. Have you had any mechanical problems with the diesel engine (e.g. plugged injectors, rings sticking, carbon buildup, etc.)? ________
   b. If so, what are the problems? ____________________
   ____
   ____
   ____
   c. How often is the engine overhauled? ____________
   d. Do you have any recommendations to help prevent or alleviate problems due to running the engine at part-load?
   ____
   ____
   ____

8. Please give your name and job title. ________________
____

9. Do you have any comments or suggestions that are not covered on this questionaire? Continue on back if necessary.________
____
____

APPENDIX B

MAILING LISTS FOR SURVEY FORMS

MAILING LIST NO. 1

ALASKA PUBLIC SCHOOL DISTRICTS

Bradley Raphel
Adak Region Schools
Adak Naval Station - Box 34
FPO Seattle, WA 98791

Spike Jorgensen
Alaska Gateway Schools
Box 226
Tok, AK 99780

LeRoy Owens
Aleutian Region School Districts
Technical Center
640 W. 36th Ave., Suite 3
Anchorage, AK 99503

E.E. "Gene" Davis
Anchorage Schools
4600 DeBarr Road
Pouch 6-614
Anchorage, AK 99502

Walter Bromenschenkel
Annette Island Schools
Box 7
Metlakatla, AK 99926

Ed Gonion
Bering Strait Schools
Box 225
Unalakleet, AK 99684

Richard Leath
Bristol Bay Borough Schools
Box 169
Naknek, AK 99633

Darrel G. Moore
Chatham Schools
Box 109
Angoon, AK 99820

Nyal Worsham
Chugach Schools
Box 638
Whittier, AK 99693

Alfred Krinke
Copper River Schools
Box 108
Glennallen, AK 99588

William Fairall
Cordova City Schools
Box 140
Cordova, AK 99574

William Milhorn
Craig City Schools
Box 71
Craig, AK 99921

Glen Chowning
Delta/Greely Schools
Box 527
Delta Junction, AK 99737

Henry Kilmer
Dillingham City Schools
Box 202
Dillingham, AK 99576

Kenneth S. Burnley
Fairbanks No. Star Borough Schools
Box 1250
Fairbanks, AK 99701

Harry Purdy
Galena City Schools
Box 299
Galena, AK 99741

Steve McPhetres
Haines Borough Schools
Box 636
Haines, AK 99827

Tom Brown
Hoonah City Schools
Box 157
Hoonah, AK 99829

Alfred Knutson
Hydaburg City Schools
Box 109
Hydaburg, AK 99922

James Zuelow
Iditarod Area Schools
Box 105
McGrath, AK 99627

MAILING LIST NO. 1 (Continued)

Michael Adams
Juneau Borough Schools
Box 808
Douglas, AK 99824

George White
Kake City Schools
Box 450
Kake, AK 99830

Fred Pomeroy
Kenai Peninsula Bor. Schools
Box 1200
Soldotna, AK 99669

Darroll Hargraves
Ketchikan Gateway Bor. Schools
Pouch Z
Ketchikan, AK 99901

Benjamin Kirker
King Cove City Schools
Box 6
King Cove, AK 99612

William Walz
Klawock City Schools
Box 9
Klawock, AK 99925

Noreen Thompson
Kodiak Island Bor Schools
Box 886
Kodiak, AK 99615

Bob McHenry
Kuspuk Schools
Box 108
Aniak, AK 99557

Jim Barnett
Lake and Peninsula Schools
Box 498
King Salmon, AK 99613

Sue Hare
Lower Kuskokwim Schools
Box 305
Bethel, AK 99559

William Phillips
Lower Yukon Schools
Box 200
Mountain Village, AK 99632

Bruce DeMond
Matanuska-Susitna Bor. Schools
Box AB
Palmer, AK 99645

Wayne Taylor
Nenana City Schools
Box 10
Nenana, AK 99760

Larry LaBolle
Nome City Schools
Box 131
Nome, AK 99762

Don Renfroe
No. Slope Borough Schools
Box 169
Barrow, AK 99723

Jim Elliot
Northwest Arctic Schools
Box 51
Kotzebue, AK 99752

Ralph Allen
Pelican City Schools
Box 603
Pelican, AK 99832

Harry Rogers
Petersburg City Schools
Box 289
Petersburg, AK 99833

Leland Dishman
Pribilof Schools
St. Paul Island, AK 99660

Jim Paul
Railbelt School District
Drawer 129
Healy, AK 99743

Colin Baxter
St. Marys School District
Box 171
St. Marys, AK 99658

Liz Boario
Sand Point School District
Box 158
Sand Point, AK 99661

Arthur Woodhouse
Sitka Borough Schools
Box 179
Sitka, AK 99835

David Lannigan
Skagway City Schools
Box 497
Skagway, AK 99840

Bob Weinstein
Southeast Island Schools
Box 8340
Ketchikan, AK 99901

Peter Flisock
Southwest Region Schools
Box 196
Dillingham, AK 99576

Ken Lease
Tanana City Schools
Box 89
Tanana, AK 99777

Robert Mutch
Unalaska City Schools
Pouch 260
Unalaska, AK 99685

Lewis Simpson
Valdez City Schools
Box 398
Valdez, AK 99686

Robert McConnell
Wrangell City Schools
Box 651
Wrangell, AK 99929

John Novak
Yakutat City Schools
Box 427
Yakutat, AK 99689

Roger Neunsinger
Yukon Flats Schools
Box 359
Ft. Yukon, AK 99740

Joe Cooper
Yukon/Koyukuk Schools
Box 309
Nenana, AK 99760

MAILING LIST NO. 2

Contents: Alaskan Power Utilities

Date: 6/12/85

Nancy Gross
City of Akutan
P.O. Box 557
Dutch Harbor, AK 99692

William A. Corbus
Alaska Electric Light & Power Company
134 North Franklin St.
Juneau, AK 99801

Vernon Neitzer
Alaska Power & Telephone Company
P.O. Box 1
Skagway AK 99840

Julie Dirks
Andreanof Electric Corp.
Atka Rural Branch
Atka, AK 99502

Artie H. Demandel
Aniak Light and Power Company, Inc.
P.O. Box 2
Aniak, AK 99557

Candace B. Knight
Arctic Utilities, Inc.
4706 Harding Drive
Anchorage, AK 99503

Robert M. Burke
Barrow Utilities and Electric Coop., Inc.
P.O. Box 449
Barrow, AK 99723

Thomas Sterrett, Jr.
Bethel Utilities Corporation, Inc.
P.O. Box 729
Eagle River, AK 99577

Daryl G. Morris
Bettles Light & Power, Inc
General Delivery
Bettles, AK 99726

Arlene Kopun
City of Chignik
General Delivery
Chignik, AK 99564

Virgil OR Sandra James
Christochina Trading Post
Mile 32, Tok Highway
Gakona, AK 99586

Richard Hutchinson D/B/A
Circle Electric
Circle City, AK 99733

David L. Highers
Copper Valley Electric Association, Inc.
P.O. Box 45
Glennallen, AK 99588

W.D. Bechtel
Cordova Electric Cooperative, Inc
P.O. Box 20
Cordova, AK 99574

Homer Lee Leonard D/B/A
Egegik Light and Power
P.O. Box 109
Egegik, Alaska 99579

Gary L. Ferguson
G & K, Inc.
P.O. Box 173
Sand Point, AK 99661

Charles Y. Walls
Glacier Highway Electric Association, Inc.
P.O. Box 210547
Auke Bay, AK 99821

Faye D. Hughes
Gwitchyaa Zhee Utility Company
Box 476
Clam Gulch, AK 99568

Cory Hilderbrand
Haines Light & Power Co., Inc.
134 N. Franklin
Juneau AK, 99801

B. Kent Wick
Homer Electric Association, Inc.
P.O. Box 429
Homer, AK 99603

Trig Olsen
I-N-N Electric Cooperative, Inc.
P.O. Box 111
Iliamna, AK 99606

Richard D. Newland
City of Ketchikan Public Utilities
P.O. Box 7300
Ketchikan, AK 99901

Lamar Cotten
City of King Cove
P.O. Box 37
King Cove, AK 99612

Edwin K. Kozak
Kodiak Electric Association, Inc.
P.O. Box 787
Kodiak, AK 99615

Benjamin Kamkoff
City of Kotlik
General Delivery
Kotlik, AK 99620

Francis D. Sheldon
Kotzebue Electric Association, Inc.
P.O. Box 44
Kotzebue, AK 99752

Frank D. Nicori
Kwethluk Inc.
P.O. Box 80
Kwethluk, AK 99621

Dave McClure
Levelock Electric Cooperative, Inc.
Levelock, AK 99625

Margaret Patrick D/B/A
M & D Enterprises
P.O. Box 66
Galena, AK 99741

Jerry L. Hook
Manley Utility Co., Inc.
Manley Hot Springs, AK 99756

Nels Franklin
Manokotak Power Co.
Manokotak, AK 99628

James A. Vanderpool
McGrath Light & Power Co.
Box 52
McGrath, AK 99627

Claude E. Franke
Naknek Electric Association, Inc.
P.O. Box 118
Naknek, AK 99633

Frank Nelson
Napakiak Ircinaq Power Co.
General Delivery
Napakiak, AK 99634

Charles G. Evans
Umnak Power Company D/B/A
The Native Village of Nikolski
Nikolski, AK 99638

Dean Wolfe
City of Nome D/B/A
Nome Light and Power Utilities
P.O. Box 70
Nome, AK 99762

Johnny Adams
North Slope Borough D/B/A
North Slope Power & Light System
Box 546
Barrow, AK 99723

Clarence L. Larsen
Northway Power & Light, Inc.
P.O. box 410
Northway, AK 99764

Robert F. Dryden
Nushagak Electric Cooperative, Inc.
P.O. Box 10-1008
Anchorage AK 99511

Stanley F. Brown
Paxson Lodge, Inc.
Mi. 185 Richardson Hwy.
Paxson, AK 99737

Jana Wienchoski
Pelican Utility Company
P.O. Box 601
Pelican AK, 99832
Howard Thacke
City of Petersburg
P.O. Box 329
Petersburg, AK 99833

Weldon S. Holmes D/B/A
Semloh Supply
Lake Minchumina, AK 99623

Everett P. Diener
City of Seward
P.O. Box 167
Seward, AK 99664

Fermin Gutierrez
City of Sitka
Box 79
Sitka, AK 99835

Paula E. Eller
Tanana Power Company, Inc.
P.O. Box 876
Palmer, AK 99645

Robert R. Blodgett
Teller Power Company
No.2 Grantly Ave.
Teller, AK 99778

Courtland H. Ofelt
City of Thorne Bay
P.O. Box 110
Thorne Bay, AK 99950

Jarrett Broughton
Tlingit-Haida Regional Electrical Authority
P.O. Box 210149
Auke Bay, AK 99821

Carl McConnell
City of Unalaska
Pouch 89
Unalaska, AK 99685

Weisner Trading Co.
Rampart AK 99767

Joyce Rasler
City of Wrangell
P.O. Box 531
Wrangell, AK 99929

Frederick O. Miller
Yakutat Power Inc.
P.O. Box 257
Yakutat, AK 99689

MAILING LIST NO. 3

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

Maintenance Director
Department of Transportation and
Public Facilities
Chandalar, AK

Maintenance Director
Department of Transportation and
Public Facilities
Coldfoot, AK

Maintenance Director
Department of Transportation and
Public Facilities
Jim River, AK

Maintenance Director
Department of Transportation and
Public Facilities
7-Mile, AK

Maintenance Director
Department of Transportation and
Public Facilities
Livengood, AK

Maintenance Director
Department of Transportation and
Public Facilities
Steese, AK

Maintenance Director
Department of Transportation and
Public Facilities
Cantwell, AK

Maintenance Director
Department of Transportation and
Public Facilities
East Fork, AK

Maintenance Director
Department of Transportation and
Public Facilities
Trimms, AK

Maintenance Director
Department of Transportation and
Public Facilities
Gardiner Creek, AK

Maintenance Director
Department of Transportation and
Public Facilities
Sag River, AK

Maintenance Director
Department of Transportation and
Public Facilities
Dietrich, AK

Maintenance Director
Department of Transportation and
Public Facilities
South Fork, AK

Maintenance Director
Department of Transportation and
Public Facilities
O'Brien Creek, AK

Maintenance Director
Department of Transportation and
Public Facilities
Eagle, AK

Maintenance Director
Department of Transportation and
Public Facilities
Deadhorse, AK

Maintenance Director
Department of Transportation and
Public Facilities
Central, AK

Maintenance Director
Department of Transportation and
Public Facilities
Tok, AK

Maintenance Director
Department of Transportation and
Public Facilities
Montana Creek, AK

MAILING LIST NO. 4

MISCELLANEOUS

Ron Moore
Department of Transportation and
Public Facilities
P.O. Box 973
Kodiak, AK 99615

Village of Tatitlek
Gary Kompkoff, President
General Delivery
Tatitlek, AK 99677

Gabbert's Camp
Alexander Creek, AK 99698

Village of Chenega Bay
Larry Evanoff, President
General Delivery
Chenega Bay, AK 99562

Noatak Village Council
Noatak, AK 99761

APPENDIX C

RETURNED SURVEYS FROM SCHOOL DISTRICTS (R6-SCHOO)

LOCATION	ARTIFICIAL LOADING?	MECHANICAL PROBLEMS WITH DIESEL ENGINE	COMMENTS OR SUGGESTIONS (list any recommendations, observations, etc. made on survey)
Bering Straits Sch. Dist:	Used infrequently	"engines running less than 2/3 capacity tend to carbon badly, get out of tune quicker, and require more frequent overhauls-particularly head work."	MTBO answers apply to entire school district. No individual information available. These figures are "off the top of my head" (Micheal Rohn 7/8/85)
Brevig Mission			
Little Diomede		"Probably the largest single problem is low voltage or 'brown out'. Letting the sets run out of fuel, imroper load transfer practices and poor maintenances are primary (causes)..." i.e. operator error.	-Comments: Alternate between gensets. Recommends using (he uses) 5kw res. heater to raise loads. Not a good idea to "rob waste heat off of a set running less than 2/3 cap."
White Mountain			
Southeast Island Sch.Dist:			This information was obtained per phone conversation between JG and Ralph Gregory 7/2/85 and the subsequent info. sent by latter.
Edna Bay			
Hollis School			
Port Alexander			
Meyers Church			
Thorne Bay (camp)			
Thorne Bay (school)			gensets are being run alternately.
Tanana City Sch. Dist.	no	no problems	last time overhauled 11/80. no comments or recommendations.
Kenai Penninsula Sch.Dist.			

RETURNED SURVEYS FROM SCHOOL DISTRICTS (R6-SCHOO)

LOCATION	GENSET SIZE: (kw)	MODEL	DIESEL MANUF.	GEN. MANUF.	AVE. LOAD yearly (%)	AVE. LOAD summer (%)	AVE. LOAD winter (%)	FUEL CONSUM. yearly (gal)	FUEL CONSUM. summer (as is)	FUEL CONSUM. winter (as is)	FUEL EFFICIENCY (kWh/gal)	MTBO (hours)
Bering Straits Sch. Dist:												2-3 yrs
Brevig Mission	85		Perkins		2/3							
	2 X 135		Caterpillar		2/3							
Little Diomede	2 X 50		Caterpillar		3/4							
	2 X 80		Caterpillar		3/4							
White Mountain	2 X 85		John Deere		3/4							
	2 X 85		Detroit Diesel									
Southeast Island Sch.Dist:												
Edna Bay	7.50	A7-5S2LI	Lister									
	12	TS-33-1893	Lister									
Hollis School	2 X 12	TS-33-1893	Lister									
Port Alexander	2 X 50	NL-1276	Northern Lights									
Meyers Church	2 X 10	4.108		Perkins								
Thorne Bay (camp)	125										11.5 kWh/gal	
	150											
	300											
	500											
Thorne Bay (school)	2 X 90	3304	Caterpillar		31.90						10.8 kWh/gal	
Tanana City Sch. Dist.	100	D324	Caterpillar	Caterpillar		25-30	25-30		288 gal	288 gal		
Kenai Penninsula Sch.Dist.	10 X 125	Varies	Varies	Kohler		35	25-100		150 gal	1100 gal		

APPENDIX D

RETURNED SURVEYS FROM A.P.U.C. VILLAGES (RS-APUC)

LOCATION	GENSET SIZE: (kw)	MODEL	STANDBY?	DIESEL MANUF.	GEN. MANUF.	AVE.LOAD yearly (%)	AVE. LOAD summer (%)	AVE. LOAD winter (%)	FUEL CONSUM. yearly (%)	FUEL CONSUM. summer (as is)	FUEL CONSUM. yearly (%)	FUEL CONSUM. summer (as is)	FUEL CONSUM. winter (as is)	EFFICIENCY (kWh/gal)	MTBO (hours)	ARTIFICIAL LOADING?
Akutan, City of	90		no	Caterpillar			50	70		15,000 gal		15,000 gal	16,920 gal		3 yrs	no
	90						50	70		15,000 gal		15,000 gal	16,920 gal		*	no
Alaska Power & Tel. Co:																
Craig	200		comments		Caterpillar	50-80								11-12	20-25,000	
	2 X 300		comments		Fbks Morse	50-80								11-12	10,000	
	300		comments		Columbia	50-80								11-12	20-25,000	
	650		comments		Kato	85								14	20-25,000	
Hydaburg	2 X 75			Caterpillar	Caterpillar											
	90				Caterpillar											
	200				Caterpillar											
	300				Columbia		40	60						11-12	20,000	
Skagway	200			Fbks Morse	Fbks Morse		0	50						8(wintr)	10,000	
	315			Fbks Morse	Fbks Morse		0	33						8(wintr)	40,000	
	2 X 1250			Fbks Morse	Fbks Morse		40	0						10(sumr)	40,000	
Bettles Light & Power Co	250		no	Caterpillar	GE		30	40		13,000 gal		13,000 gal	20,000 gal		30-35,000	no
	2 X 300			Caterpillar	Kato		30	40		13,000 gal		13,000 gal	20,000 gal			
Copper Valley Elec. Assn.	597		no	Fbks Morse	GE		0	80							annually	no
	2624			Transamerica	Ideal		0	80								
Cordova	600															
	750															
Egegik Light & Power Co.	75			John Deere	Lima	60			< 100 gal/day		< 100 gal/day			9	15-30,000	no
	75			Caterpillar	Caterpillar	60										
Iliamna-Newhalen Elec.	320			Caterpillar	Kato		65	65		24,301 gal		24,301 gal	19,555 gal		recommend	
	320						65	65		18,392 gal		18,392 gal	40,189 gal		12,000	
	320						65	65		10,468 gal		10,468 gal	17,244 gal			
McGrath Light & Power	3 X 200	D354	yes	Caterpillar	Caterpillar											
	600	D398	no	Caterpillar	Caterpillar		40	80		70,000 gal		70,000 gal	114,000 gal			
Nome Joint Utility	300					71									30,000	
	600				Fbks Morse	77									30,000	
	600					74									30,000	
	600					75										
Pelican Seafoods, Inc.	2 X 100	D333	no	Caterpillar	Caterpillar										4-12,000	
	100	D343		Caterpillar	Caterpillar											
	200	D340B		Caterpillar	Caterpillar											
	285	1271		Detroit	Detroit											
Tanana Power Co., Inc.	350	397	yes	Caterpillar	Caterpillar		60	75		82,920 gal		82,920 gal	95,231 gal		30-40,000	
	500	398	yes	Caterpillar	Caterpillar											
	800	399	no	Caterpillar	Caterpillar											
Thorne Bay Pub. Utility	2 X 450		no	Cummins	Marathon											
	500	D348	yes	Caterpillar	Caterpillar		55-60	45								
Tlingit&Haida Reg. Elec:																
Angoon	200		yes	Caterpillar	Caterpillar		75	75		53,717 gal		53,717 gal	59,836 gal		20,000	no
	300		yes	Caterpillar	Kato											
	400		no	Caterpillar	Caterpillar											
Hoonah	2 X 610			Caterpillar	Kato		65	65		109,240 gal		109,240 gal	114,266 gal		20,000	no
Kake	300		yes	Caterpillar	Kato		60	60		93,121 gal		93,121 gal	113,352 gal		20,000	no
	500		yes	Caterpillar	Kato											
	630		no	Caterpillar	Kato											
Klawock	300		yes	Caterpillar	Kato		65	65		77,690 gal		77,690 gal	85,904 gal		20,000	no
	2 X 500		no	Caterpillar	Kato											
Unalaska, City of	2 X 300			Caterpillar	Caterpillar		60	80						11.4(sumr)	12-24,000	no
	2 X 600			Caterpillar	Caterpillar									12(wintr)		
	630			Caterpillar	Kato											
	1430			Caterpillar	EM											
Yakutat Power, Inc.	250			Caterpillar	Caterpillar	75			344,400 gal/yr		344,400 gal/yr					
	375			Caterpillar	Caterpillar											
	600			Caterpillar	Caterpillar											
	800			Chicago Pneumatic												

RETURNED SURVEYS FROM A.P.U.C. VILLAGES (RS-APUC)

LOCATION	GENSET SIZE: (kw)	MODEL	MECHANICAL PROBLEMS WITH DIESEL ENGINE (e.g. plugged injectors, rings sticking, etc.)	COMMENTS OR SUGGESTIONS (recommendations, observations, etc. made on survey)
Akutan, City of	90		None	
	90			
Alaska Power & Tel. Co:				
Craig	200			First four gensets are used for peaking and standby.
	2 X 300			
	300			
	650			
Hydaburg	2 X 75			
	90			
	200			
	300			Other generators are backup or peaking.
Skagway	200		Carbon build-up, stack fires, "puking" oil out stack.	
	315			
	2 X 1250			
Bettles Light & Power Co	250		None	Suggests changing lube oil by the book religiously.
	2 X 300			
Copper Valley Elec. Assn.	597			Using hydro-power in summer. All engines should be operated at optimum loading efficiency, but operations dictate load.
	2624			
Cordova	600			
	750			
Egegik Light & Power Co.	75		Carbon build-up in exhaust (cleaned by striking exhaust with hammer.	Check into purchasing new type high pressure injectors (John Deere).
	75			
Iliamna-Newhalen Elec.	320			
	320		Actuator malfunction	He recommends daily, monthly, & yearly maintenance to alleviate any problems including that of running part-load. Shut down maintenance is essential because machinery needs daily care.
	320			
McGrath Light & Power	3 X 200	D354		
	600	D398	Primary engine rebuilt 14-16 mo. ago as a result of gen. short circuit and overspeed of engine.	3-200 kw gens used only for back-up and scheduled oil changes. So far, no apparent problems from part-loading.
Nome Joint Utility	300			Don't part-load unless there is no alternative. Good maintenance program and quality oil & fuels will allow successful low loading.
	600			
	600			
	600			
Pelican Seafoods, Inc.	2 X 100	D333		
	100	D343		No individual fuel meters. Gen loading depends on water availability. When there is enough water, the diesels are shut On standby except for peak power. Loading varies from 25-90% all months of the year.
	200	D3408		
	285	1271		
Tanana Power Co., Inc.	350	397	None	
	500	398		
	800	399		
Thorne Bay Pub. Utility	2 X 450			
	500	D348	With 500 kw unit oil consumption problem due to lack of load	Purchase a midsize generator set to be used during summer months when load is less
Tlingit&Haida Reg. Elec:				
Angoon	200			
	300			Recommends correct sizing
	400			
Hoonah	2 X 610			Progressive planning will prevent running unit at less than 50% capacity.
Kake	300			
	500			
	630			
Klawock	300			
	2 X 500			Recommends correct sizing
Unalaska, City of	2 X 300			
	2 X 600			MTBO per specs
	630			
	1430			
Yakutat Power, Inc.	250			
	375			Not sure which generator figures are for. Shut down for oil changes and repairs.
	600			
	800			

APPENDIX E

RETURNED SURVEYS FROM DOT&PF (RS-D O T)

LOCATION	GENSET SIZE: (kw)	STANDBY?	DIESEL MANUF.	GEN. MANUF.	AVE.LOAD YEARLY ESTIMATE (%)	AVE. LOAD summer (%)	AVE. LOAD winter (%)	FUEL CONSUM. summer (as is)	FUEL CONSUM. winter (as is)	MTBO (hours)	ARTIFICIAL LOADING?
NORTHERN REGION:											
Chandalar Camp	80	No	Detroit Diesel	Lima Electric		40	75	10 gal/day	12 gal/day		No
	80	No	Detroit Diesel	Lima Electric		40	75	10 gal/day	12 gal/day		No
O'Brien Creek	22.50	No	Kohler			50		4000 gal			No
Sag River	150	See Comment	Detroit Diesel	Lima Electric		25	35	125 gal	125 gal	20,000	No
	150	See Comment	Detroit Diesel	Lima Electric		25	35	125 gal	125 gal		No
South Fork	22.50		Kohler			50		4000 gal			Yes
Tok	4.70	Yes	Witte			75		50 gals			
Montana Creek	60	No	Caterpillar		25						
	100	No	Caterpillar								
Jim River	135		Caterpillar								
	135		Caterpillar			35	40				
Livengood	100		John Deere								
	105		John Deere								
Cantwell	60		Caterpillar		67						
	90		Caterpillar		67						
East Fork	55		Caterpillar								
	60		Caterpillar								
Gardiner Creek	30		Caterpillar		70						
	30	In Storage	Caterpillar								
Central	30		Cummins		25						
	30		Cummins		25						
Deitrich	30	Not Used	Kohler								
	30	Not Used	Kohler								
Coldfoot	65		Caterpillar								
	65		Caterpillar								
7-Mile	90		Caterpillar								
	150		Caterpillar								
Steese	22.50		Kohler								
Trimms	75		John Deere								
	75		John Deere								
SOUTHCENTRAL REGION:											
Remote location	30		Caterpillar	Elec.Machine Mfg.Co.	40						No
(name not given)	50		Caterpillar	Caterpillar	25					40000	No

RETURNED SURVEYS FROM DOT&PF (RS-D O T)

LOCATION	(% OF SYSTEM CAPACITY)	MECHANICAL PROBLEMS WITH DIESEL ENGINE (e.g. plugged injectors, rings sticking, etc.)	COMMENTS OR SUGGESTIONS (list any recommendations, observations, etc. made on survey)
NORTHERN REGION:			
Chandalar Camp		Carbon buildup in crankcase ventilation tube over a period of time	Both engines overhauled in Fall 1984.
O'Brien Creek		No major problems with unit.	
Sag River		None at 18,000 hours	Alternate generators each 10 days. Recommend doing a more thorough power usage evaluation before camp is built.
South Fork	50	Oil seal went out on generator and was replaced	
Tok		None	
Montana Creek			
Jim River			
Livengood			
Cantwell			
East Fork			
Gardiner Creek			
Central			
Deitrich			
Coldfoot			
7-Mile			
Steese			
Trimms			
SOUTHCENTRAL REGION:			
Remote location (name not given)		Carbon buildup Carbon buildup	

APPENDIX F

SURVEY FORMS FROM MISCELLANEOUS SOURCES (RS-MISC.)

LOCATION	GENSET SIZE (kW)	MODEL	DIESEL MANUF.	GEN. MANUF.	AVE. LOAD yearly (%)	AVE. LOAD summer (%)	AVE. LOAD winter (%)	FUEL CONSUM. yearly (gal)	FUEL CONSUM. summer (as is)	FUEL CONSUM. winter (as is)
Alexander Creek (Gabbert's Camp)	2.5		Lister			90 - 100	90 - 100		0.3 gal/hr	0.3 gal/hr
	8.0		Lister			90	90		0.7 gal/hr	0.7 gal/hr
	12.0		Lister			90 - 100	90 - 100		1.7 gal/hr	1.7 gal/hr
Beaver	50	John Deere	John Deere	John Deere	20			15,000 gal/7mos.		
	125	John Deere	John Deere	John Deere	20					
Noatak	175		1100	Kato		50	75		3000	4000
	250		DD342	Kato		50	75		4000	5000
Takotna	50		Deutz	Kato		25 - 50	50 - 75			
	50		Deutz	Kato		25 - 50	50 - 75			

SURVEY FORMS FROM MISCELLANEOUS SOURCES (RS-MISC.)

LOCATION	FUEL EFFICIENCY (kWh/gal)	MTBO (hrs.)	ARTIFICIAL LOADING?	MECHANICAL PROBLEMS WITH DIESEL ENGINE	COMMENTS OR SUGGESTIONS
Alexander Creek (Gabbert's Camp)	7.91	5 - 7 years		In the past, all of the above (plugged injectors, rings sticking, carbon buildup), plus more.	For the past five years, I have run the genset as close as possible to their rating. This ha lead to far fewer problems than in the 10 year previous to the start of this practice.
	10.9	5 - 7 years			
	6.35	5 - 7 years			
Beaver	Approx.2.67			Changed to heavy-duty injectors.	This is a new installation, first run in late January of this year.
Noatak	6.16				
	11.5				
Takotna					

APPENDIX G

LOCATION	GENSET CAPACITY (kW)	DIESEL, MODEL	GENERATOR MAKE	LOW LOAD (%) (WEEKLY AVG.)	MONTH OF LOW LOAD	AVE.FUEL USE YEARLY BASIS (kWH/gal)	MAX.FUEL USE (lowest efficiency) MONTHLY BASIS (kWH/gal)	LOW % ENERGY EFFICIENCY	MONTH OF LOW EFFICIENCY	REMARKS (Comments correspond to genset on same line)
Alakanuk	300	D353	Kato	17.30%	July	9.10	7.70	19.00%	June	
	175	A321000	AC(K&R)							
	358	D353	Kato							Hours since last overhaul:5012
Ambler	155	6619A	Kato	48.00%	July	9.60	8.80	21.70%	June	New 12/84
	155	6619AF-00	Kato							New 9/84
	100	11000	AC(K&R)							
Anvik	100	11000	AC(K&R)	16.00%	July	7.00	6.20	15.30%	July	Engine Hrs.- 15552
	50	3500	AC(K&R)							Engine Hrs.- 11408
	50	2900	KAMB 18							Engine Hrs.- 35209
Chevak	300	D353	Kato	53.80%	July	10.00	9.20	22.70%	June	Engine Hrs.- 28683
	160	D342	Kato							
	350	D353	Kato							
Eek	106	D342	Kato	10.50%	July	7.10	6.70	16.50%	July	
	53	3500	AC(K&R)							Electric Governor
Elim	106	D342NA	Kato	24.80%	July	9.10	7.60	18.80%	July	Engine Hrs.-46919
	125	685I	AC(K&R)							New - 1/85
	75	3500	Kato							Engine Hrs.- 55835, Installed used 12/84
Emmonak	175	21000	AC(K&R)	23.70%	June	8.10	7.80	19.30%	May	Engine Hrs.- 22849, Overhaul 12/14/80
	300	D353	Kato							
	300	D353E	Kato							
Gambell	160	D342	Kato	44.40%	June	10.10	9.50	23.50%	April,August	Engine Hrs.- 20334, Overhaul 9/21/80
	250	25000	Norwood							Overhaul 5/21/82
	300	D353	Kato							
Goodnews Bay	100	11-16280	Kato	33.30%	June	9.20	8.20	20.20%	May	Engine Hrs.- 23, Overhaul 3/9/78
	75	3012321	Kato							Overhaul 8/20/83
Grayling	50	3500	AC(K&R)	24.80%	July	9.40	8.60	21.20%	March	Engine Hrs.- 34613, Overhaul 3/8/78
	75	3500	AC(K&R)							Engine Hrs.- 45913, Overhaul 7/20/81
	125	685I	AC(K&R)							
Holy Cross	160	D352T	Kato	23.00%	July	8.00	7.30	18.00%	August	
	125	685I	AC(K&R)							
Hooper Bay	175	2100MKII	AC(K&R)	24.00%	July	10.80	9.80	24.20%	June,July	Engine Hrs.-18463, Overhaul 5/3/76
	300	D353	Kato							
	300	3412	Kato							
Huslia	50	3500	AC(K&R)	25.80%	July	9.30	8.30	20.50%	May	Engine Hrs.-213988, Overhaul 10/26/80
	75	6-71	Kato							Engine Hrs.-33754, Overhaul 5/25/82
	155	3306 DITA	Kato							Engine Hrs.- 3, New 11/84
Kaltag	105	8V-71	Kato	38.10%	July	9.20	8.00	19.80%	June	
	105	8V-71	Kato							Engine Hrs.-210025, Overhaul 7/8/81
	155	6619A	Kato							Engine Hrs.-1
Kiana	250	D353E	Kato	19.30%	June	10.60	8.50	21.00%	November	
	300	D353E	Kato							Engine Hrs.-21845, Overhaul 2/11/83
	100	11000	AC(K&R)							Engine Hrs.-20792, Overhaul 6/10/74
	225	3406	Kato							
Kivalina	160	D342	Kato	28.70%	June	9.50	8.00	19.80%	June	Engine Hrs.-20787, Overhaul 12/10/79
	300	D353	Kato							
	150	6519A	Lima							Engine Hrs.-39 (new unit)
Koyuk	120	685I	Kato	30.70%	June	9.40	8.50	21.00%	June	
	105	685I	AC(K&R)							Engine installed 1/85
	75	3500	KAMAG18							Engine Hrs.-35096, Overhaul 3/10/80
Lower Kalskag	160	D342	Kato	33.70%	May	9.40	8.00	19.80%	July	
	160	D342	Kato							
Marshall	150	685I	AC(K&R)	22.70%	July	9.40	8.00	19.80%	July	Start-up date: 4/7/84
	110	685I	Kato							Start-up date: 4/12/84
Mekoryuk	75	3500	AC(K&R)	24.70%	July	9.80	8.40	20.70%	June	
	150	685I	AC(K&R)							In service 1/84
	100	685I	KAMAG18							In service 1/84
Minto	90	3304	Kato	24.40%	June	9.50	6.80	16.80%	June	In service 8/11/84
	75	6-71	EM BEMACII							
	85	3500	Kato							Engine Hrs.-28776, Overhaul 5/19/83

Mountain	300	3412	Kato	27.90%	June	12.10	11.00	27.20%	April	In service 4/14/84
Village	300	D353E	Kato							Engine Hrs.-18614, Overhaul 4/6/80
	440	3512	Kato							
New	105	8V-71	Kato	34.00%	June	7.70	5.90	14.60%	Sept.,Nov.	Engine Hrs.-14385, Overhaul 3/15/79
Stuyahok	150	685I	AC(K&R)							In service 12/84
	50	4-71	Kato							Engine Hrs.-21960, Overhaul 8/1/83
Noatak	160	D342	Kato	28.10%	July	9.10	7.30	18.00%	July	Engine Hrs.-15257, Overhaul 12/27/79
	115	11000	Kato							Engine Hrs.-22247, Overhaul 5/15/81
Noorvik	175	D342	Kato	24.00%	July	11.60	11.00	27.20%	June	
	300	3412	Kato							Not in service.
	300	3412	Kato							In service 4/84
Nulato	300	D343E	Kato	14.30%	June	9.10	7.80	19.30%	June,July	
	175	D342	Kato							
	250	D353E	Kato							
Nunapitchuk	198	D353	Kato	19.20%	July	10.20	7.80	19.30%	December	Engine Hrs.-37325, Overhaul 8/30/82
	265	D353	Kato							
Old	155	3306B	Cat	27.70%	June	10.00	9.20	22.70%	June	Engine Hrs.-17959
Harbor	155	3306B	Cat							Engine Hrs.-20499
Pilot	110	685I	Kato	18.00%	June	10.50	9.10	22.50%	June	Engine Hrs.-66382, Overhaul 3/7/80
Station	106	D342	Kato							Needs Overhaul
	150	6519A	Lima							
Quinhagak	160	D342	Kato	36.30%	March	9.50	8.20	20.20%	August	
	150	6619A	Lima							
	75	3500	KAMAG18							
										Engine Hrs.-25708, Overhaul 2/22/78
Savoonga	250	D353	Kato	29.00%	July	10.90	10.40	25.70%	June	Engine Hrs.-47953, Overhaul 9/23/83
	300	D353	Kato							
	100	11000	KAMAG18							
										Engine Hrs.-14782, Overhaul 10/16/74
Scammon	110	6-71	Kato	14.50%	April	8.60	7.00	17.30%	June	Engine Hrs.-45125, Overhaul 12/29/83
Bay	75	4-71	Kato							
	105	8V-71	Kato							
Selawik	250	D353	Kato	23.50%	July	9.80	8.30	20.50%	June	
	300	D353	Kato							
	100	11000	AC(K&R)							
										Engine Hrs.-20095, Overhaul 4/28/76
Shageluk	50	2900	KAMAG18	N/A	N/A	8.10	7.00	17.30%	May	Engine Hrs.-29703, Overhaul 4/24/81
	75	3500	KAMAG18							Engine Hrs.-40399, Overhaul 3/24/83
	75	3500	KAMAG18							Engine Hrs.-58623, Overhaul 4/3/83
Shaktoolik	75	3500	KAMAG18	29.30%	July	8.70	7.40	18.30%	June	
	75	685I	Kato							Engine Hrs.-31691, Overhaul 8/15/81
	50	2900	KAMAG18							Engine Hrs.-3 (in service 10/20/84)
										Engine Hrs.-34375, Overhaul 12/16/79
Shishmaref	300	D353	Kato	24.00%	June	9.60	9.00	22.20%	June,August, September	
	300	D353	Kato							
Shungnak	105	8V-71	Kato	51.40%	June	10.80	8.00	19.80%	June	
	175	3406B	Caterpillar							
										New engine - 11/84
St. Marys	600	D398	Kato	24.00%	June	10.80	8.70	21.50%	June	
	600	D398	Kato							
	300	D353E	Kato							
										Engine Hrs.-28766, Overhaul 6/10/82
St.	105	8V-71	EM	28.10%	August	10.30	8.10	20.00%	October	Engine Hrs.- 10883, Overhaul 6/2/83
Michael	150	635I	AC(K&R)							
	160	D352	Kato							
Stebbins	150	685I	K&R	30.00%	July	9.60	8.20	20.20%	July	
	125	11000	AC(K&R)							New unit with electric governor.
	110	6-71	KAMAG18							Engine Hrs.-6612, Overhaul 12/14/83
										Engine Hrs.-1377
Togiak	300	D353	Kato	14.00%	September	9.50	8.30	20.50%	June	
	300	D353	Kato							Engine Hrs.-6707 Overhaul 10/20/81
	160	D342	Kato							Engine Hrs.-16889, Overhaul 4/4/80
										Engine Hrs.-13966, Overhaul 3/24/80
Toksook	300	D353	Kato	16.00%	July	8.60	6.80	16.80%	June	
Bay	150	635I	AC(K&R)							
	150	685I	AC(K&R)							In service 8/17/84
	150	6519A	Lima							In service 7/26/84
										Not yet installed
Tununak	125	635I	AC(K&R)	10.40%	July	8.10	6.40	15.80%	August	
	125	635I	AC(K&R)							New (0 hrs)
	50	3500	AC(K&R)							New (0 hrs)
										Engine Hrs.-32499, Overhaul 10/2/80
Wales	105	8V-71	Kato	28.00%	June	8.60	6.70	16.50%	November	
	75	3500	Kato							
	50	4-71	Kato							Overhaul 1/15/84
										Engine Hrs.-32499, Overhaul 4/25/80

APPENDIX H

ORIGINAL AMBLER DATA

VILLAGE Ambler During Week Starting MONDAY - Month June Year 85 ALASKA VILLAGE ELECTRIC CO-OPERATIVE, INC. **PLANT OPERATING LOG**

H1

Check plant regularly and make all required entries THREE TIMES DAILY. After completion this log must be placed in mail to AVEC Headquarters on Monday morning - DO NOT DELAY!

READ INSTRUCTION FILL IN ALL REQUIRED INFORMATION

CARRY OVER— last log entry from previous week.	1 UNIT POSITION	2 TIME OF DAY	3 INSIDE TEMP.	4 OUTSIDE TEMP.	EXHAUST SMOKE A. BLUE B. BLACK: CLEAR	VISIBLE	THICK	5 TOTAL ENGINE HOURS READING FROM ☐ ENGINE METER ☐ PANEL METER	6 ENGINE COOLANT, TEMP.	7 ENGINE OIL TEMP.	8 ENGINE OIL PRESS	9 EXHAUST, TEMP. RECORD F°	10 CRANKCASE, BACK PRESS RECORD INCHES	11 AIR FILTER RESTRICTION RECORD INCHES	12 DATE AIR FILTER CHANGED	13 DATE FUEL FILTER CHANGED	14 DATE LUBE OIL CHANGED	15 DATE LUBE OIL FILTER CHANGED	16 QUARTS OF LUBE OIL ADDED	17 BATTERY VOLTAGE	18 QUARTS COOLANT ADDED	19 CHECK UGS OIL LEVELS
CARRY OVER	2	835P	80	68	✓			4648	185	195	47								0	28		
MONDAY Date 24	2	8Am	64	56	✓			4660	185	195	47								2	28		
	2	4Pm	74	64	✓			4668	185	195	47								0	28		
	2	810P	72	60	✓			4672	185	190	47								0	28		
TUESDAY Date 26	2	850A	60	58	✓			4685	185	190	47								6	28		
	2	3Pm	78	72	✓			4691	185	200	47								0	28		
	2	930P	76	64	✓			4697	185	195	47								0	28		
WEDNESDAY Date 26	2	850A	68	68	✓			4709	185	170	47								2	28		
	2	315P	68	54	✓			4715	185	190	47								0	28		
	2	730P	64	50	✓			4720	185	190	47								0	28		
THURSDAY Date 27	2	830A	62	54	✓			4733	189	190	47								2	28		
	2	3PM	76	64	✓			4739	185	190	47								0	28		
	2	810P	80	64	✓			4744	185	190	47								0	28		
FRIDAY Date 28	2	830A	72	58	✓			4756	185	190	47								0	28		
	2	330P	70	58	✓			4763	185	190	47								1	28		
	2	9Pm	70	58	✓			4769	185	190	47								0	28		
SATURDAY Date 29	2	810A	70	54	✓			4780	185	190	47								0	28		
	2	2Am	66	13	✓			4787	185	195	49								0	28		
	2	12am	74	14	✓			4796	185	195	47								0	28		
SUNDAY Date 30	2	12pm	66	8	✓			4808	185	195	49								8	28		
	2	3pm	68	12	✓			4811	185	195	49								8	28		
	2	9pm	74	14	✓			4817	185	195	49								0	28		

CARRY OVER— last log entry from previous week.	20 TOTAL KWH GENERATED	KW DEMAND (RESET POINTER. AFTER RECORDING)	21 STATION KWH METER READING	22 STATION FREQUENCY (Before Adjusting)	23 STATION VOLTAGE	24 PHASE 1 CURRENT IN AMPS	25 PHASE 2 CURRENT (Three Phase ONLY)	26 PHASE 3 CURRENT IN AMPS	27 INSTANTANEOUS KW	28 POWER FACTOR	29 DAY TANK FUEL METER— TOTAL READING AFTER FILLING	30 GALLONS PUMPED INTO DAY TANK AT EACH FILLING	31 OPERATORS INITIALS
CARRY OVER	5066	0.32	33961	60	480	95	120	40	70	98			D.S.
MONDAY Date 24	5068	0.24	34022	60	480	40	80	20	55	98			D.S.
	5070	0.36	34066	60	480	125	125	35	85	1	393137	143	D.S.
	5071	0.34	34090	60	480	105	130	25	80	1			D.S.
TUESDAY Date 26	5073	0.28	34155	60	480	80	90	35	50	1			D.S.
	5075	0.3	34199	60	480	105	100	20	70	1	393269	132	D.S.
	5076	0.28	34225	60	480	80	140	20	75	1			D.S.
WEDNESDAY Date 26	5078	0.24	34285	60	480	95	100	20	70	98			D.S.
	5080	0.28	34320	60	480	100	135	30	75	98	393404	134	D.S.
	5081	0.28	34394	60	480	90	80	20	60	1			D.S.
THURSDAY Date 27	5083	0.28	34425	60	480	100	100	30	70	1			D.S.
	5084	0.28	3445[illegible]	60	480	100	120	25	75	98	393536	131	D.S.
	5085	0.28	34463	60	480	100	95	35	70	98			D.S.
FRIDAY Date 28	5088	0.26	34556	60	480	75	60	20	55	1			D.S.
	5089	0.28	34595	60	480	105	115	30	80	1	393672	136	D.S.
	5091	0.3	34626	60	480	60	80	25	60	98			D.S.
SATURDAY Date 29	5092	0.24	34694	60	480	60	50	25	50	1			D.S.
	5094	0.32	34732	60	480	105	125	45	95	.99	393806	133	J.C.
	5096	0.32	34781	60	480	90	95	40	60	.98			JC
SUNDAY Date 30	5099	0.25	34857	60	480	95	105	45	72	.99			JC
	5099	0.29	34871	60	480	95	130	45	75	.99	393943	137	JC
	5100	0.3	34905	60	480	50	120	45	65	.99			JC

AVEC 7-0033

7

PLANT INSPECTION DATE ______________

UTILITY BOARD/COUNCIL INITIALS ______________

DO NOT WORK ON HOT WIRES — SHUT PLANT DOWN AND LOCK DOOR WITH YOUR OWN LOCK.

36/3

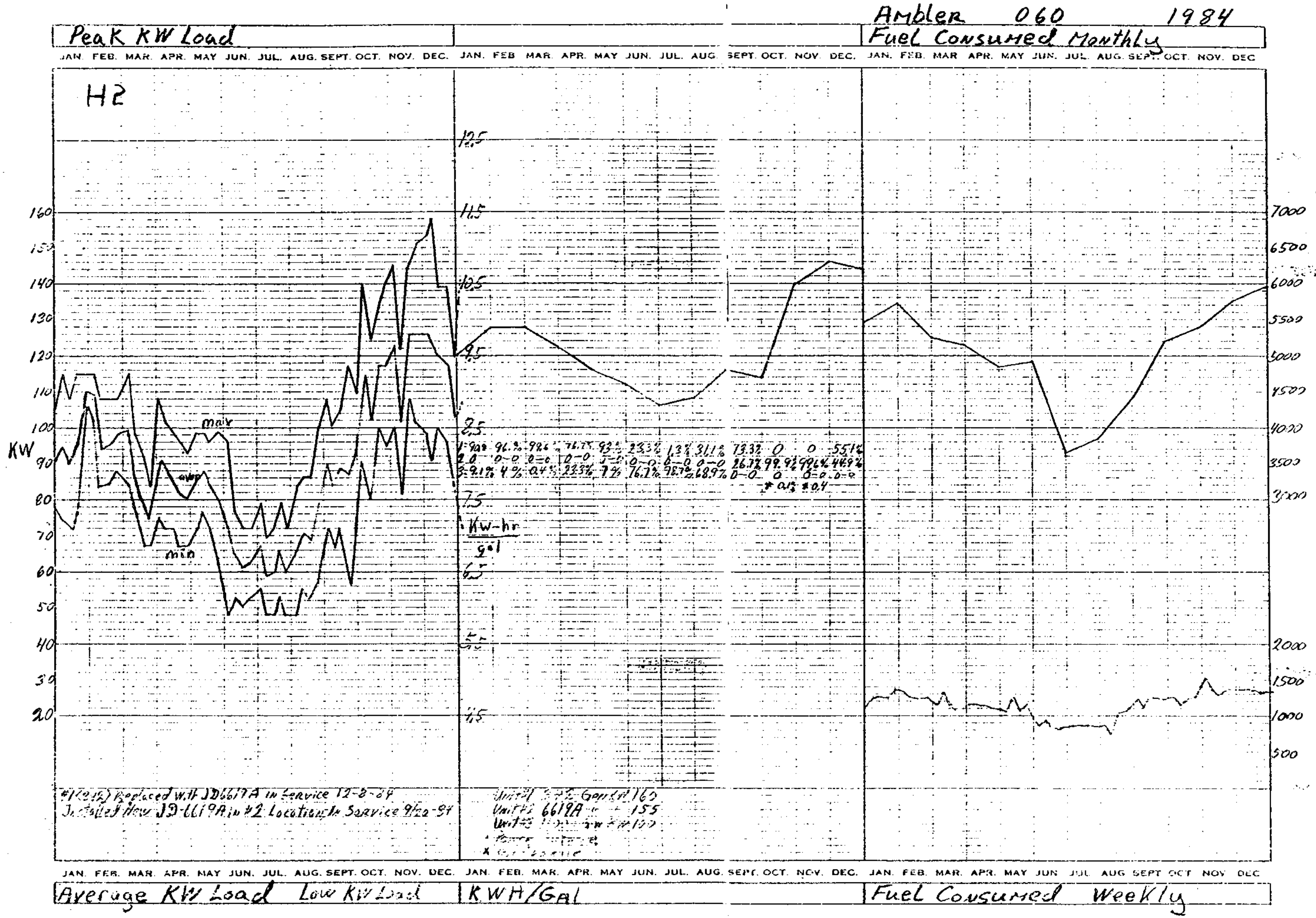
FILL IN ALL REQUIRED INFORMATION ON BACK SIDE OF THIS LOG.

950 - 946

CARRY OVER — EACH TIME YOU START A NEW WEEKLY LOG COPY DOWN THE LAST LOG ENTRY FROM PREVIOUS WEEK.

KEEP WEEDS OUT BACK 10 FEET AROUND POWERHOUSE & TANKS. MAINTAIN A CLEAN, SAFE PLANT, INSIDE AND OUT, THAT YOU CAN BE PROUD OF.

USE AVEC STANDARD REQUISITION FOR ALL PARTS & MATERIAL ORDERS.



Ambler 060 1984
Peak KW Load
Fuel Consumed Monthly
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT. OCT. NOV. DEC.
H2
KW
max
avg
min
Kw-hr / gal
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20
12.5 11.5 10.5 9.5 8.5 7.5 6.5 5.5 4.5
7000 6500 6000 5500 5000 4500 4000 3500 3000 2000 1500 1000 500
73.3% 0 0 55.1%
26.7% 99.9% 99.6% 44.9%
* 0.1% * 0.4
#1(2.12) Replaced with JD6619A in Service 12-8-84
Installed New JD-6619A in #2 Location In Service 9/20-84
Unit #2 6619A 155
Average KW Load Low KW Load
KWH/Gal
Fuel Consumed Weekly

H3

	Jan 84 744	Feb 696	March 744	April 720	May 744
	Ld	Ld	Ld	Ld	Ld
072 Alakanuk Total KWH	77000 178 ✓	76400 188 ✓	73000 194	65800 168 ✓	59600 166
Fuel	7918 ✓	7546 ✓	7358 ✓	6928 ✓	7215 ✓
KWH Net	74261	73917	71132	64351	57932
KWH/Gal	9.7	10.1	9.9	9.5	8.3
#1 Hrs — oil	226—48	0—0	576—38	276—55	216—52
#2 Hrs — oil	0—0	351—13	168—4	0—0	0—0
#3 Hrs — oil	518—76	345—72	0—0	444—52	528—88
KWH sold	62791	54013	67395	55836	39121
oil Chgs	1	1	0	2	2
(+) Excess hrs (-) Hrs Down P/0					

	Jan 84	Feb	March	April	May
060 Ambler Total KWH	55680 115	51840 115	49440 108	44820 101	44830 92
Fuel	5629 ✓	5241 ✓	5171 ✓	4830 ✓	4908 ✓
KWH net	48733	46920	44671	39838	39960
KWH/Gal	9.9	9.9	9.6	9.3	9.1
#1 Hrs — oil	676—156	668—160	741—110	552—138	692—187
#2 Hrs — oil	0—0	0—0	0—0	0—0	0—0
#3 Hrs — oil	68—8	28—0	3—0	168—21	52—0
KWH sold	48915	64382	50449	33038	41559
oil Chgs	4	3	2	3	3
(+) Excess hrs (-) Hrs Down P/0					

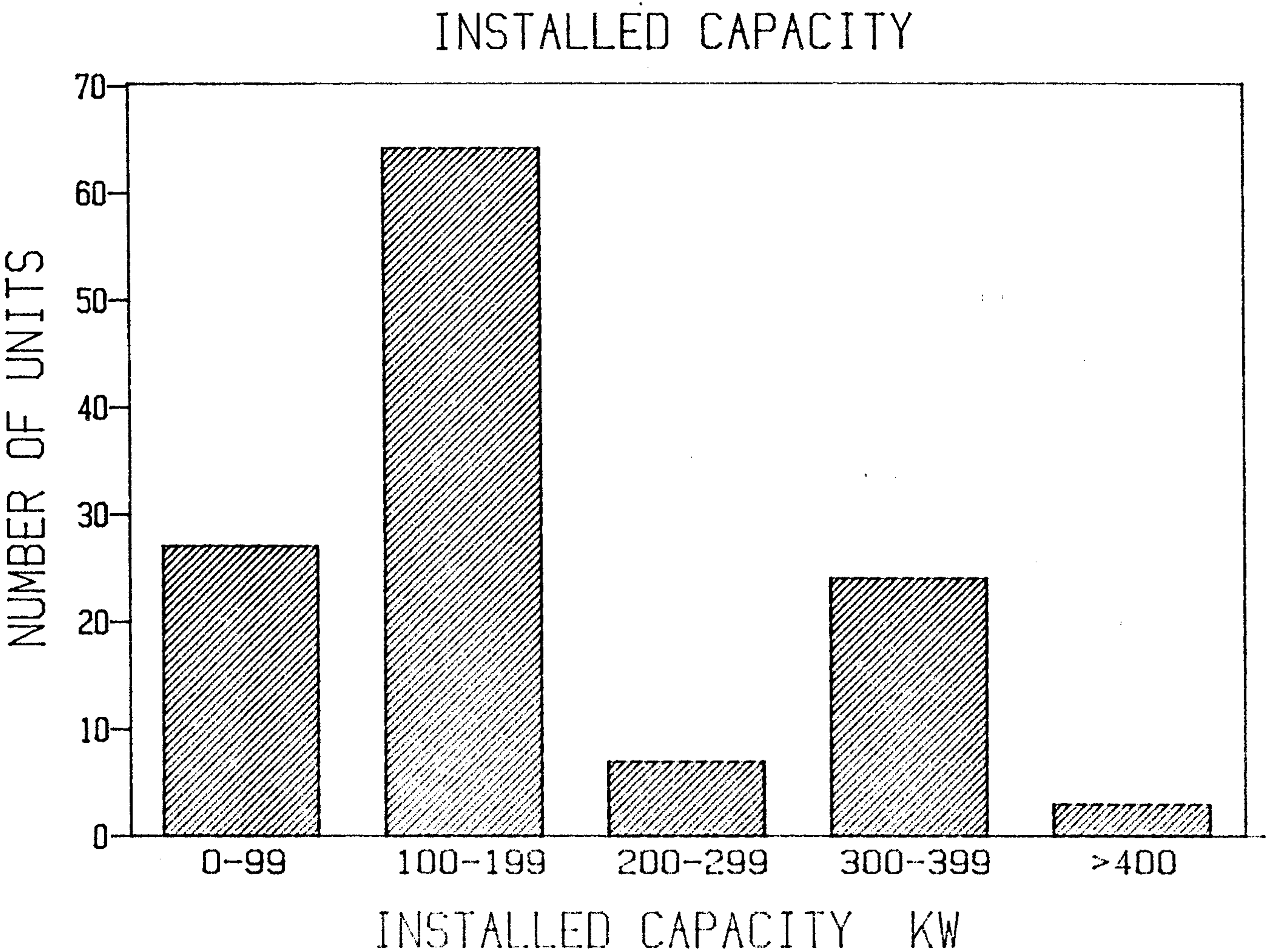
	Jan 84	Feb	March	April	May
051 Anvik Total KWH	18080 53	16720 50	18720 48	17120 42	16160 [illegible]
Fuel	2377 ✓	2457 ✓	2743 ✓	2504 ✓	2481 ✓
KWH Net	16511	15332	17501	15429	14787
KWH/Gal	7.6	6.8	6.8	6.8	6.5
#1 Hrs — oil	168—4	528—74	72[illegible]—77	45[illegible]—72	701—76
#2 Hrs oil	552—55	48—0	0—0	264—24	[illegible]
#3 Hrs oil	24—0	120—0	18—10	4—0	[illegible]—0
KWH Sold	13443	11333	14147	11242	12519
oil Chgs	2	3	4	4	
(+) Excess hrs (-) hrs Down P/0 1					

	Jan 84	Feb	March	April	May
014 Chevak Total KWH	81000 202 ✓	77760 194 ✓	78480 [illegible] ✓	71640 191	[illegible]
Fuel	7830	7242	7590 ✓	7121 ✓	[illegible] ✓
KWH Net	79818	755[illegible]	76409	63441	64897
KWH/Gal	10.3	[illegible]	10.3	10.1	[illegible]
#1 Hrs — oil	96—0	6—0	0—0	0—0	[illegible]
#2 Hrs — oil	96—2	0—0	3—0	0—0	[illegible]—55
#3 Hrs — oil	552—148	690—156	741—162	718—120	444—62
KWH sold	54573	77421	69920	78815	71839
oil Chgs	3	3	3	2	
(+) Excess Hrs (-) Hrs Down 170				-2	

June 720	July 744	Aug 744	Sept 720	Oct 744	Nov 720	Dec. 744	Year 8784
Ld	Ld	Ld	Ld	Ld	Ld	Ld	Ld
44500 [illegible]	40600 [112]	5[illegible]00 [75]	62800 [178]	69400 [176]	72200 [178]	78400 [188]	77220
5800 ✓	5198 ✓	6041 ✓	6521 ✓	7746 ✓	7532 ✓	8202 ✓	8500
42692	38257	49506	60965	68261	56283	76441	73399
7.7	7.8	8.6	9.6	9.0	9.6	9.6	AV. 9.
264—49	648—28	717—50	496—85	578—95	591—67	725—116	5313—74
0—0	0—0	27—0	204—0	166—44	129—35	19—0	1064—9
456—44	96—0	0—0	20—48	0—0	0—0	0—0 8784-1219	2407—38
36753	35413	38487	53889	60898	57669	74048	636313
3	1	1	3	4	2	3	23
32400 [77]	34320 [82]	41040 [108]	48000 [118]	57600 [145]	62400 [154]	63600 [156]	58603
3689 ✓	3869 ✓	4398 ✓	5233 ✓	5490 ✓	5767 ✓	5936 ✓	60161
30014	31052	37251	42188	51605	56283	57274	525789
8.8	2.9	9.3	9.2	10.5	10.8	10.7	AV. 9.6
168—62	10—0	231—18	528—81	0—0	0—0	410—55	4676—96
0—0	0—0	0—0	192—35	743—125	717—114	334—33	1986—307
52—48	734—28	513—28	0—0	0—0	0—0	0—0 8784-1407	2118—133
26480	33077	40257	46326	56767	56217	67858	565305
3	1	1	2	4	3	2	31
				-1	-3		-4
1[illegible] [30]	13680 [40]	15[illegible] [43]	16880 [46]	19680 [53]	19040 [52]	19420 [48]	20[illegible]
2094 ✓	2220 ✓	2268 ✓	2322 ✓	2494 ✓	2428 ✓	2277 ✓	23665
12023	12572	13573	15561	18015	17432	17337	186073
6.5	6.2	6.6	7.3	7.9	7.8	8.1	AV. 7.0
56—24	468—56	110—24	136—0	48—24	41—0	17—0	3851—431
60—2[illegible]	132—3	615—46	524—74	696—77	679—81	727—82	4594—488
4—0	144—10	19—0	0—0	0—0	0—0	3—0 8784-939	339—20
7529	9994	10321	10770	14417	13055	11249	142139
2	3	3	3	4	3	3	38
51120 [122]	55440 [122]	68400 [194]	74880 [209]	87480 [252]	90000 [216]	874[illegible] [220]	890280
5563 ✓	5[illegible] ✓	6903 ✓	7421 ✓	8329 ✓	8560 ✓	8604 ✓	87846
50615	51[illegible]	67646	73200	85746	88352	85769	870[illegible]
9.2	9.4	9.9	10.1	10.4	10.5	10.2	AV. 10.
0—0	0—0	300—58	696—106	740—150	717—102	740—157	3295—570
18—110	626—166	120—56	24—0	4—0	3—0	4—0	2258—389
2—0	[illegible]—0	24—48	0—0	0—0	0—0	0—0 8784-1655	[illegible]—696
5[illegible]	55456	66805	64511	83679	88022	86791	844751
2 8	3	3	2	3	2	4	32
							-10

APPENDIX I

BAR GRAPHS FOR AVEC VILLAGES


INSTALLED CAPACITY
NUMBER OF UNITS
0
10
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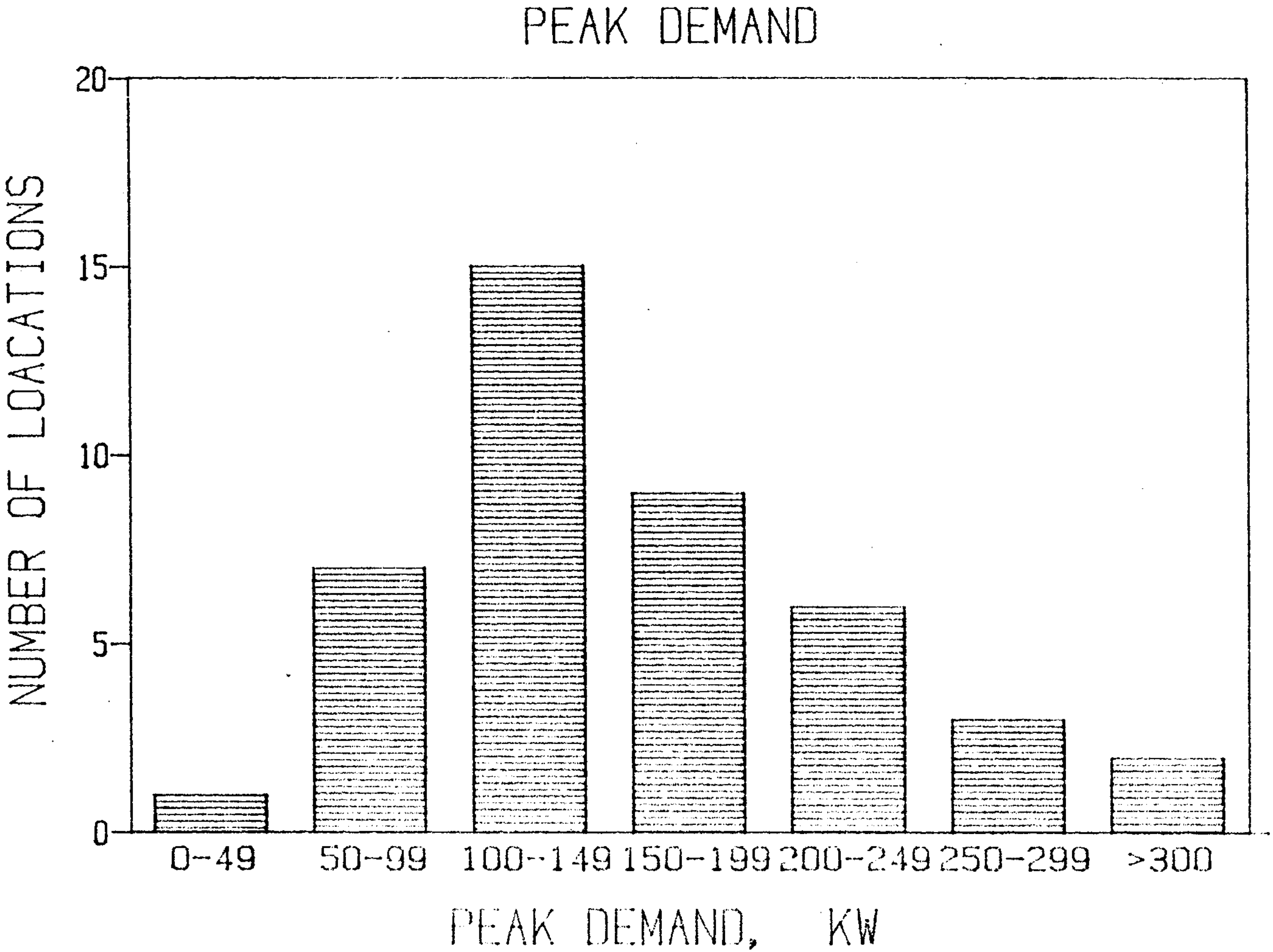
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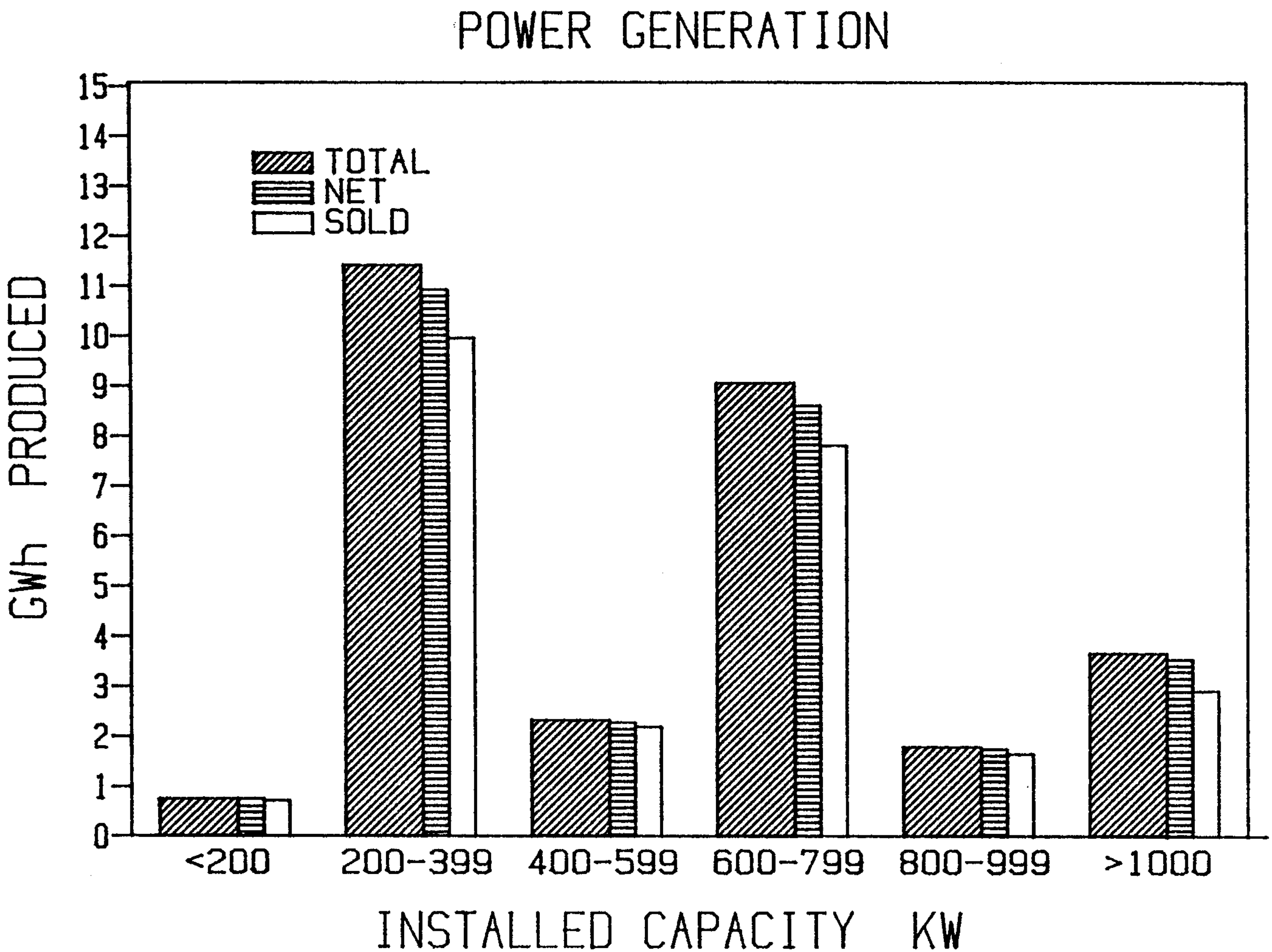
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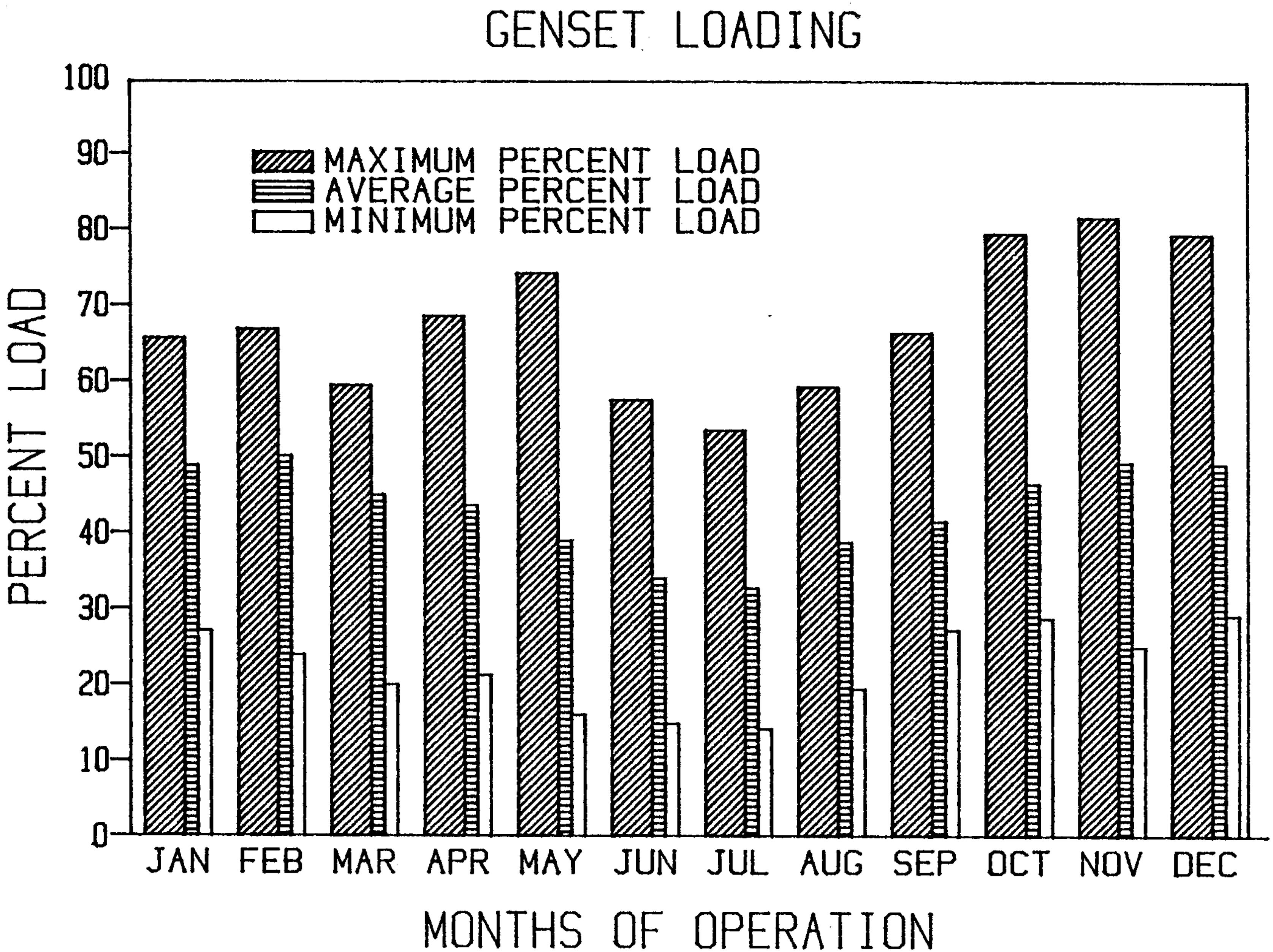

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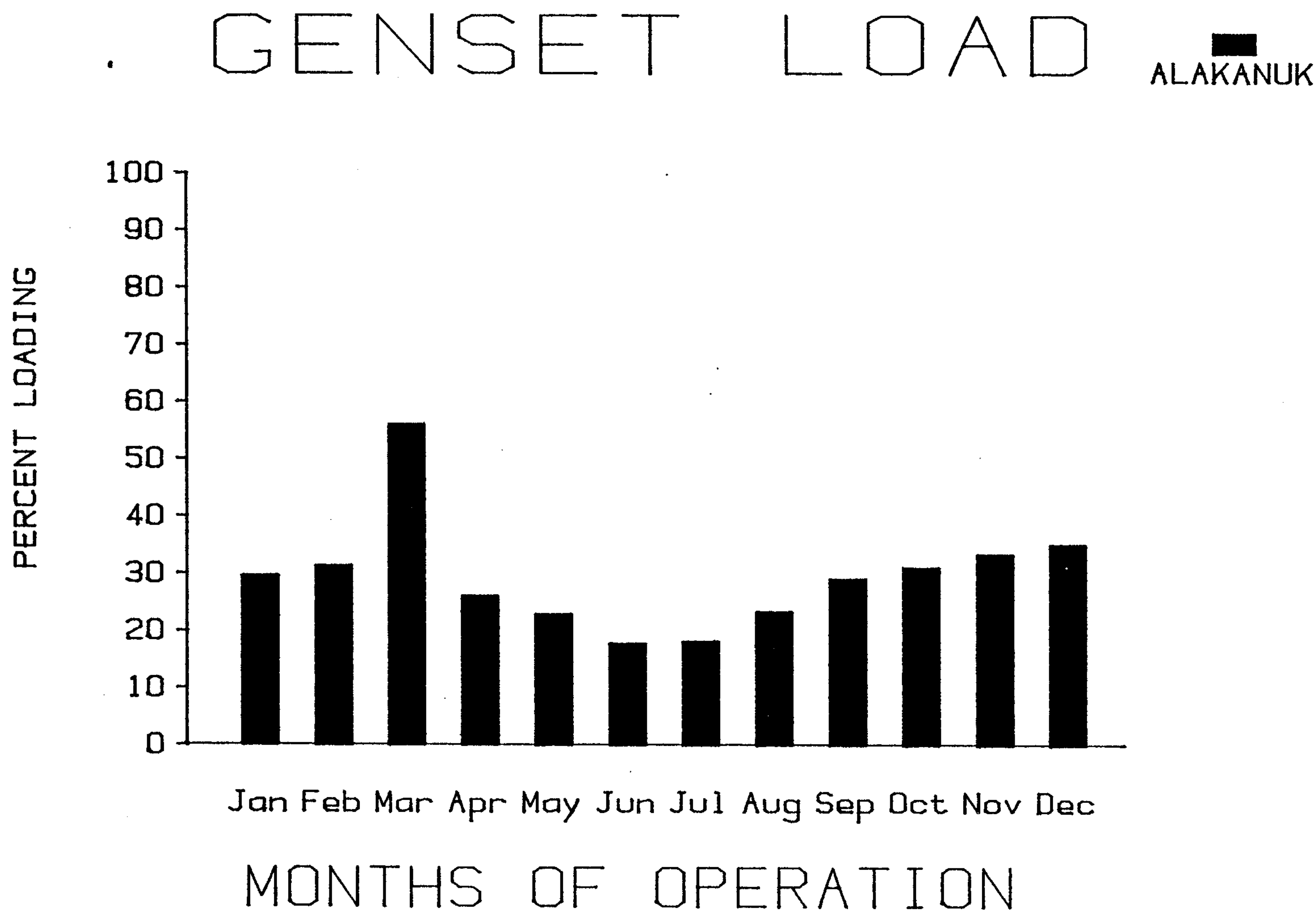
MONTHS OF OPERATION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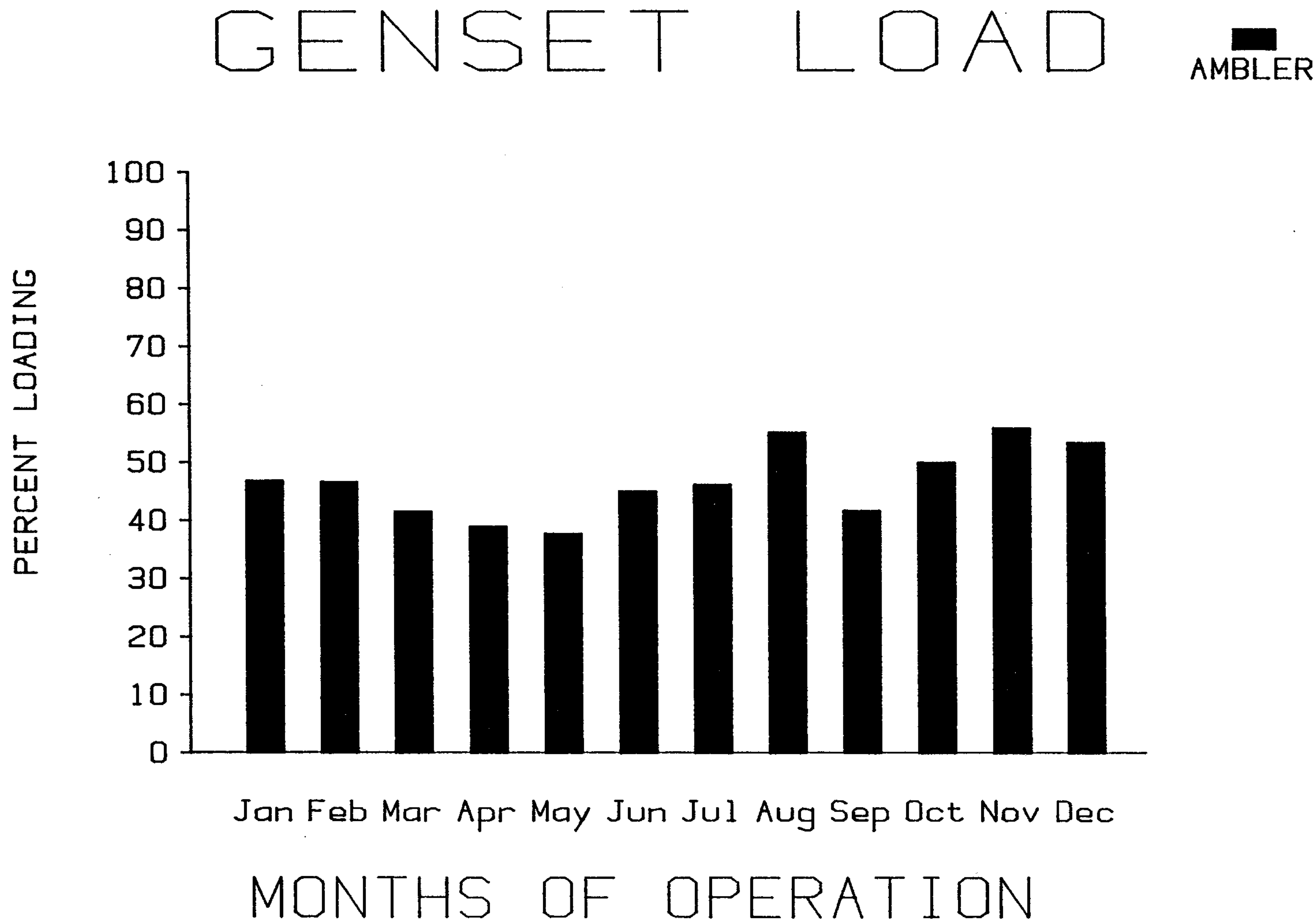
MONTHS OF OPERATION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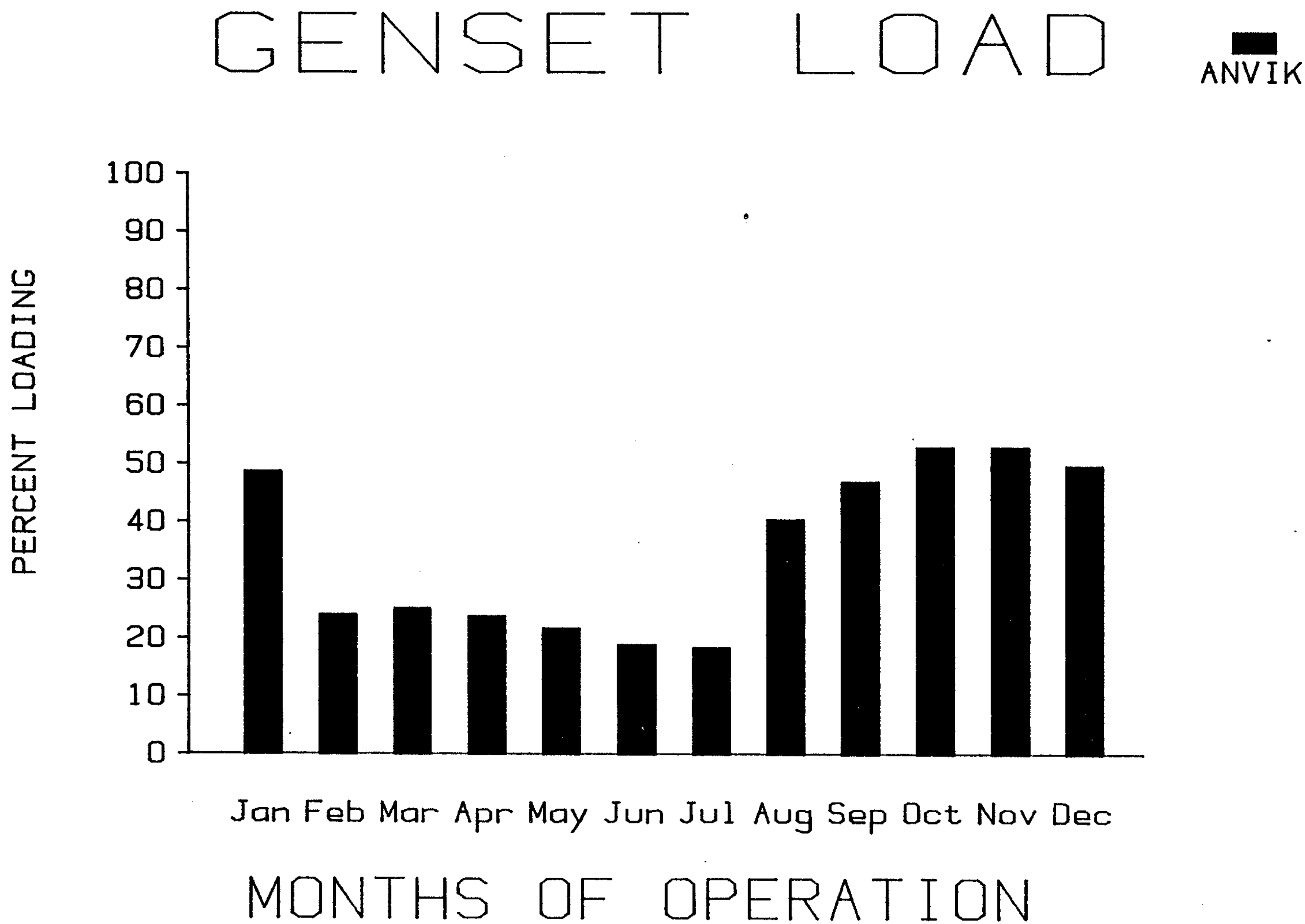
MONTHS OF OPERATION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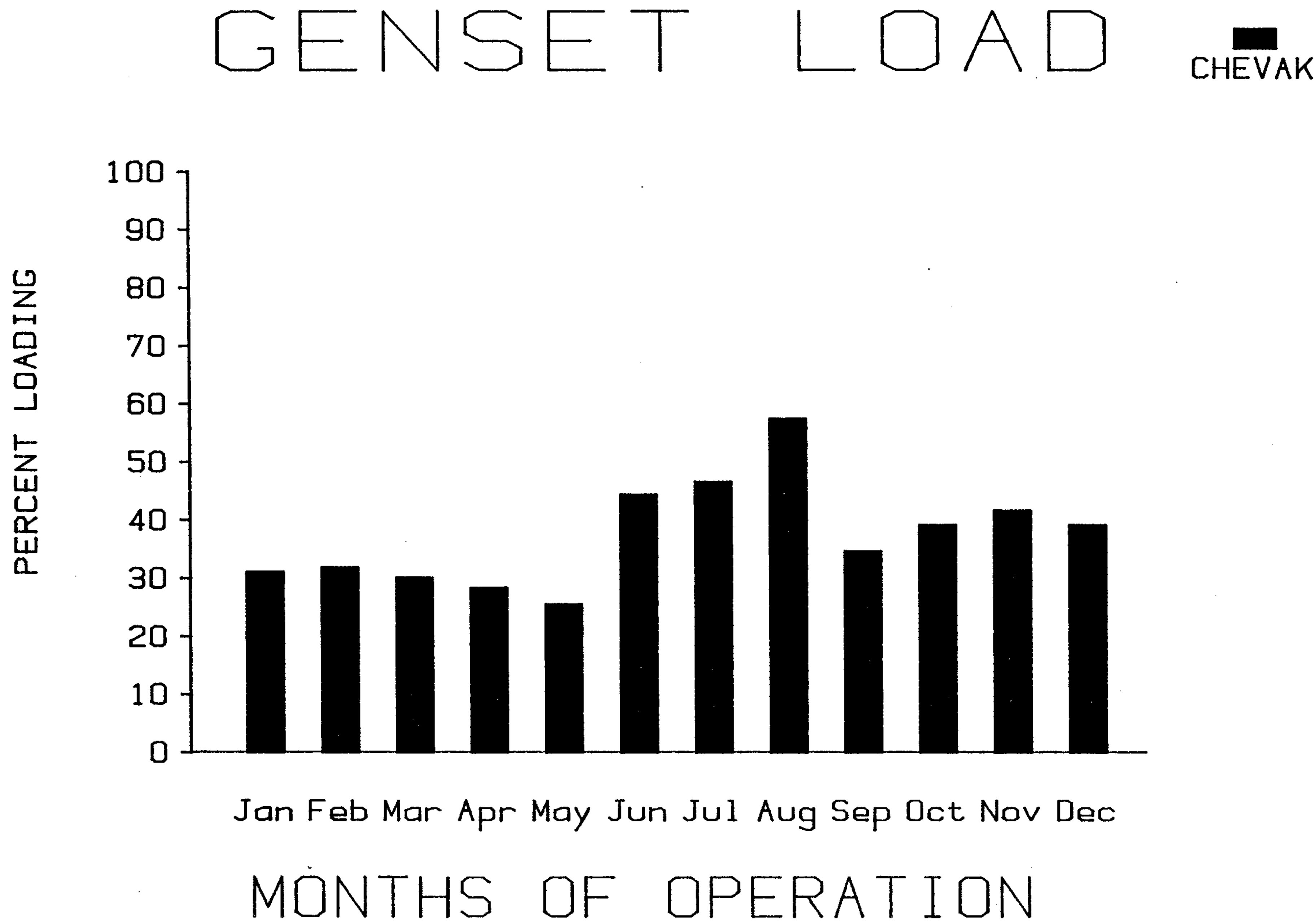
MONTHS OF OPERATION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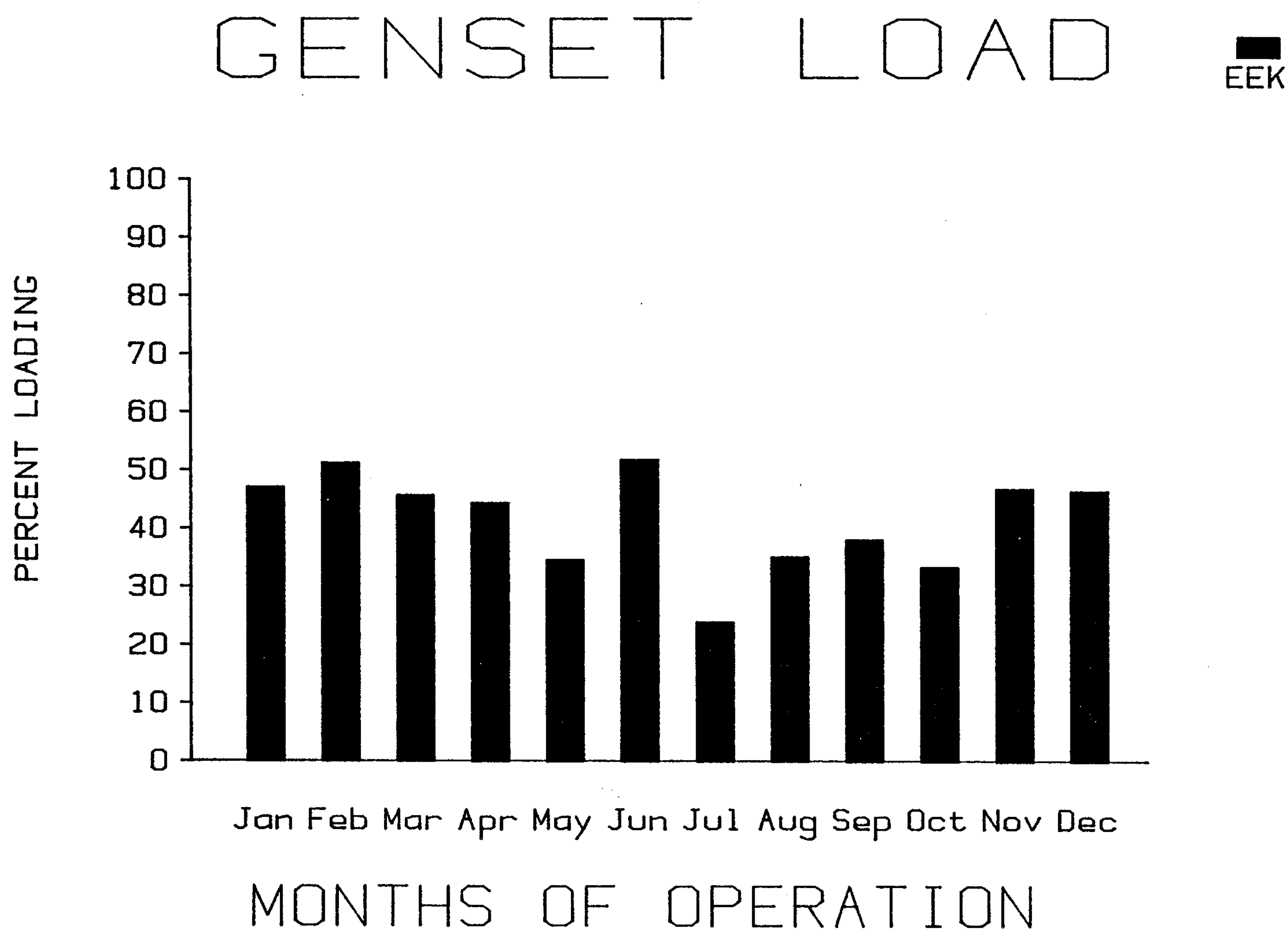
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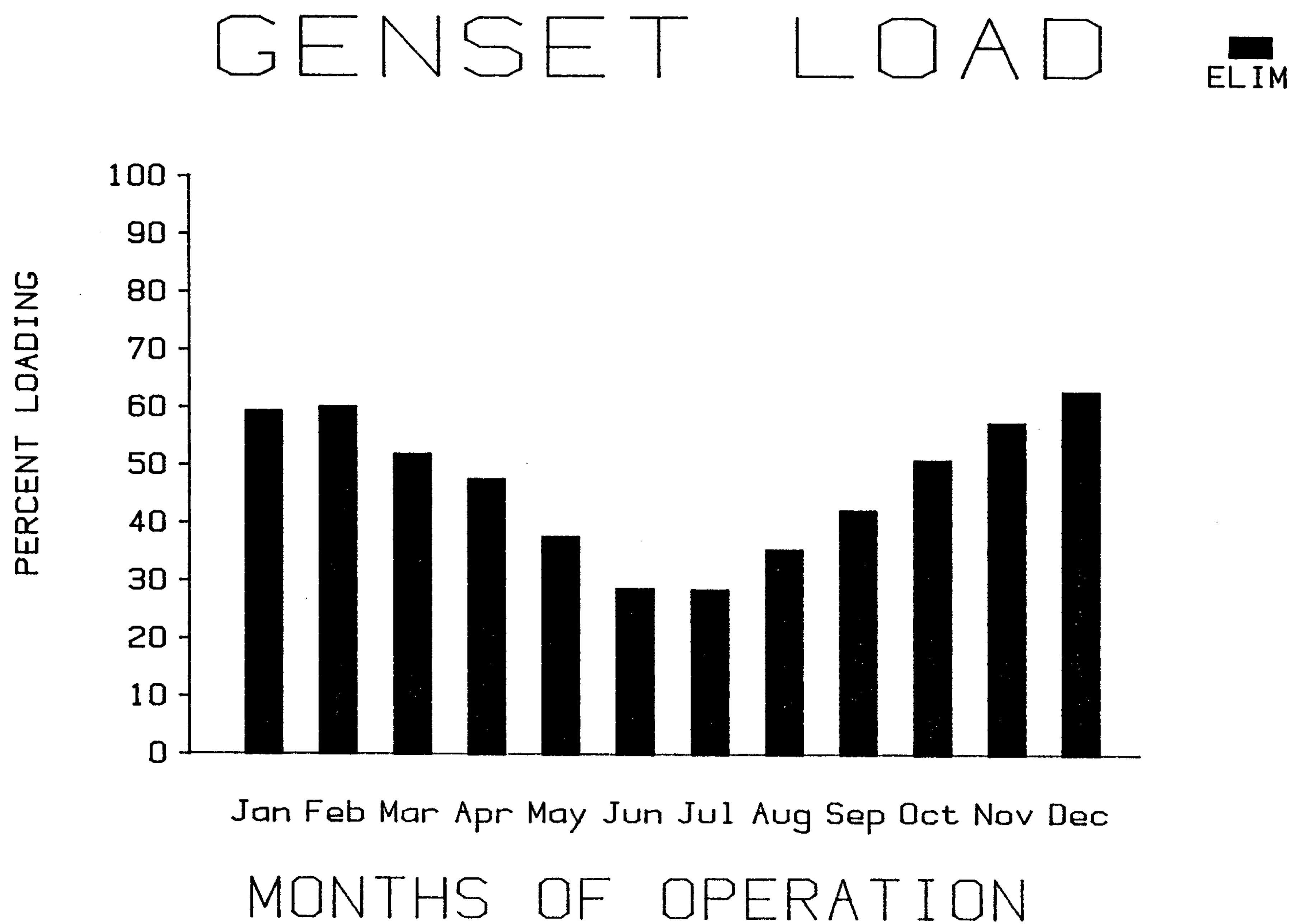
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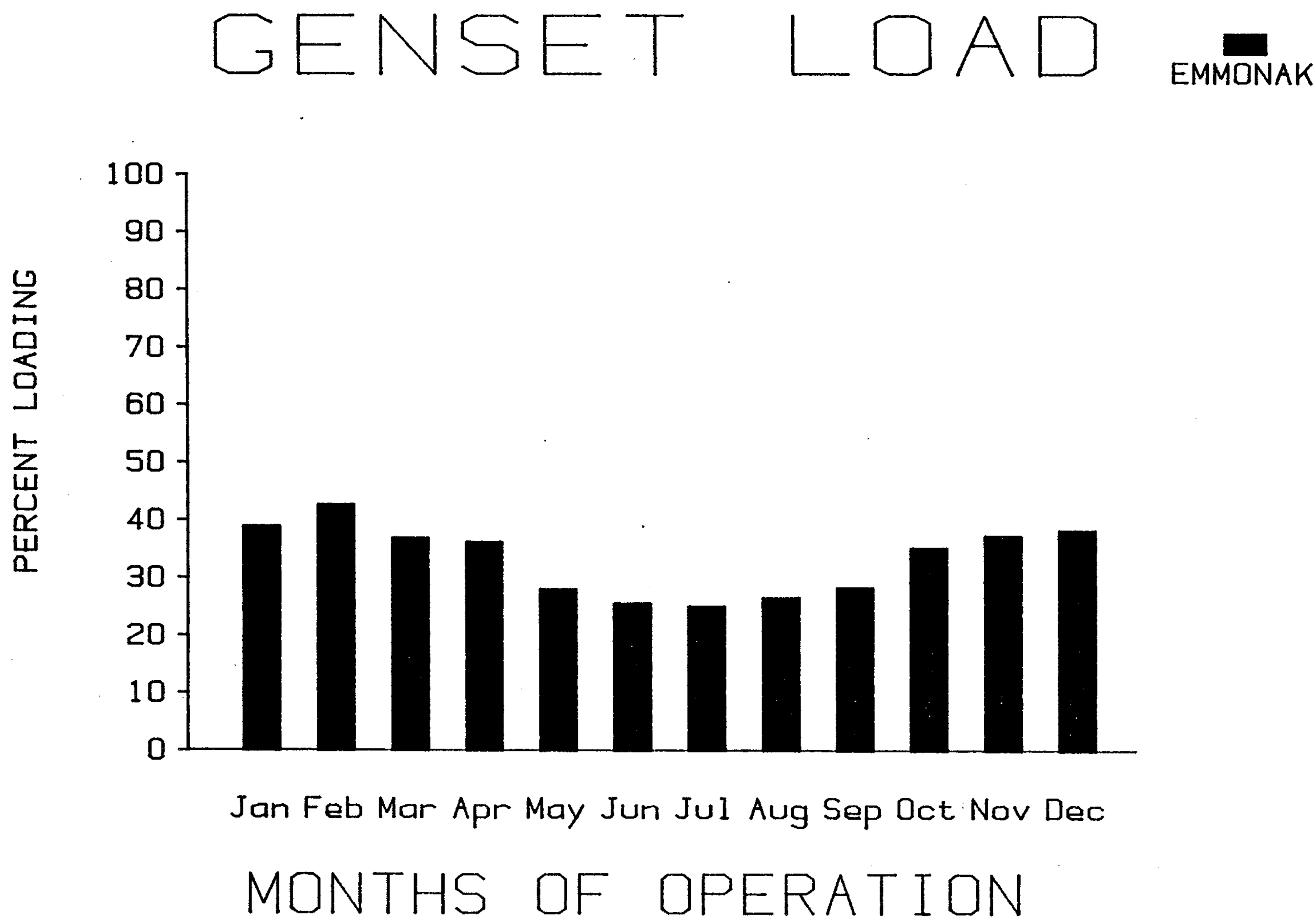
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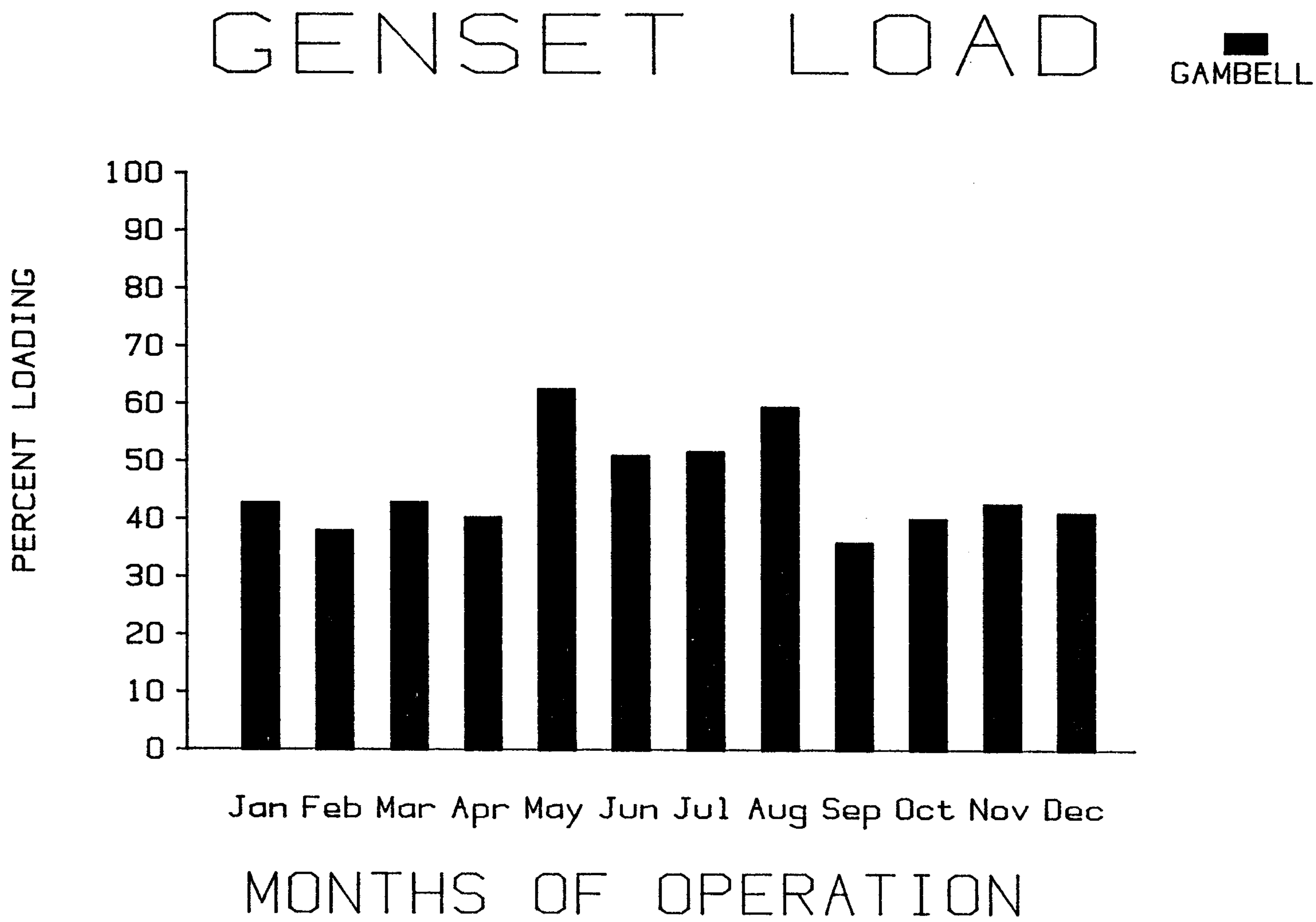

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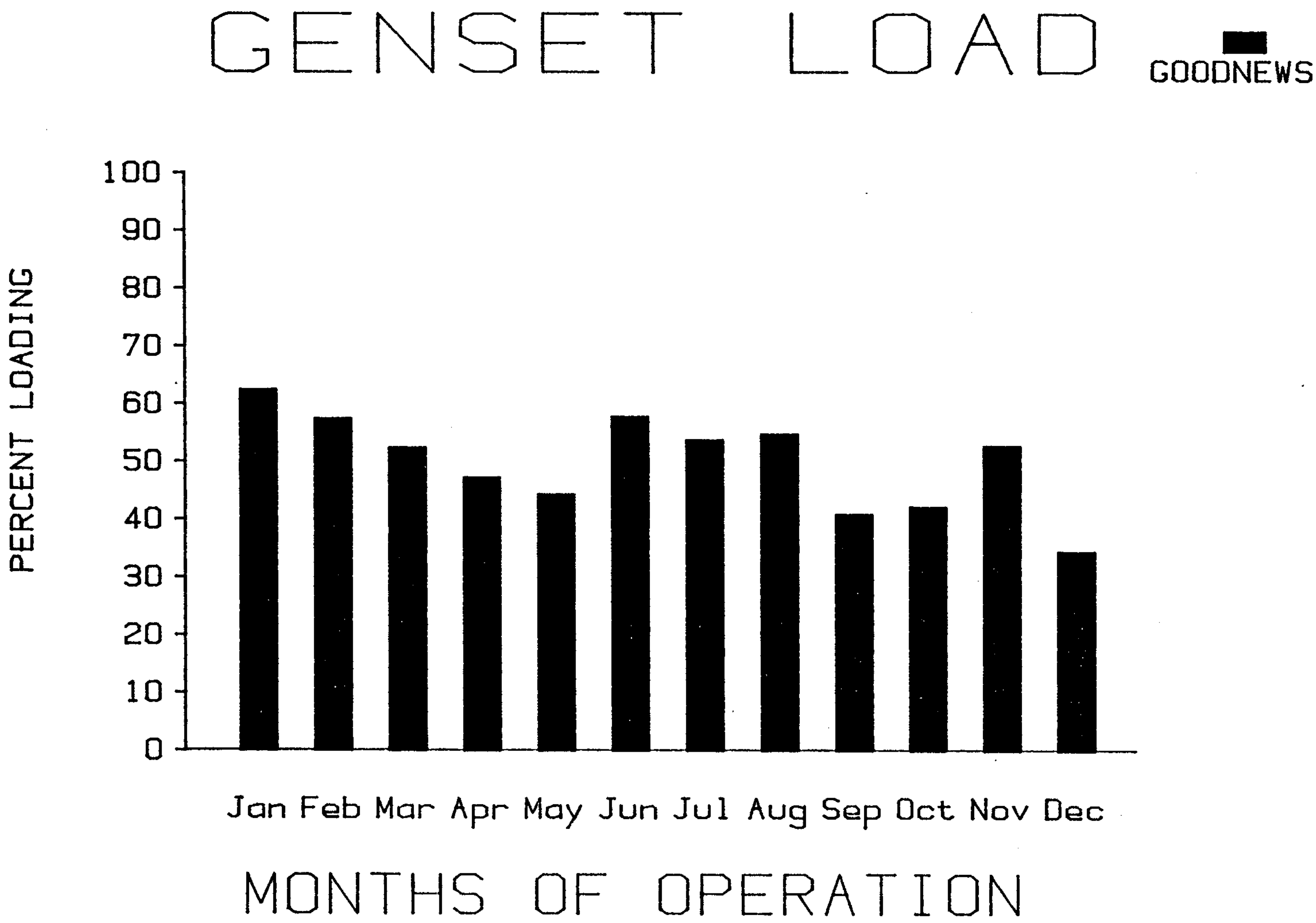
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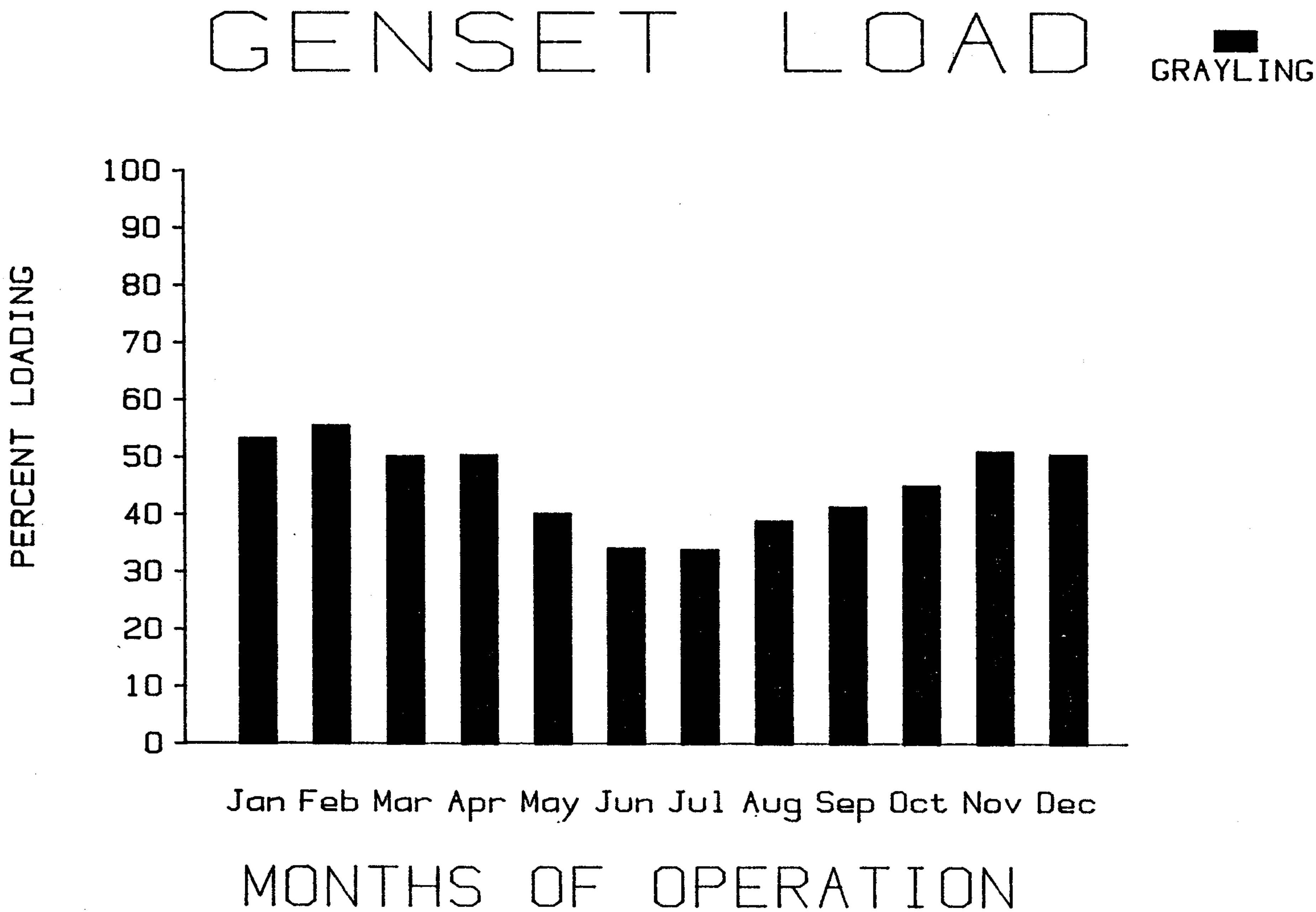
MONTHS OF OPERATION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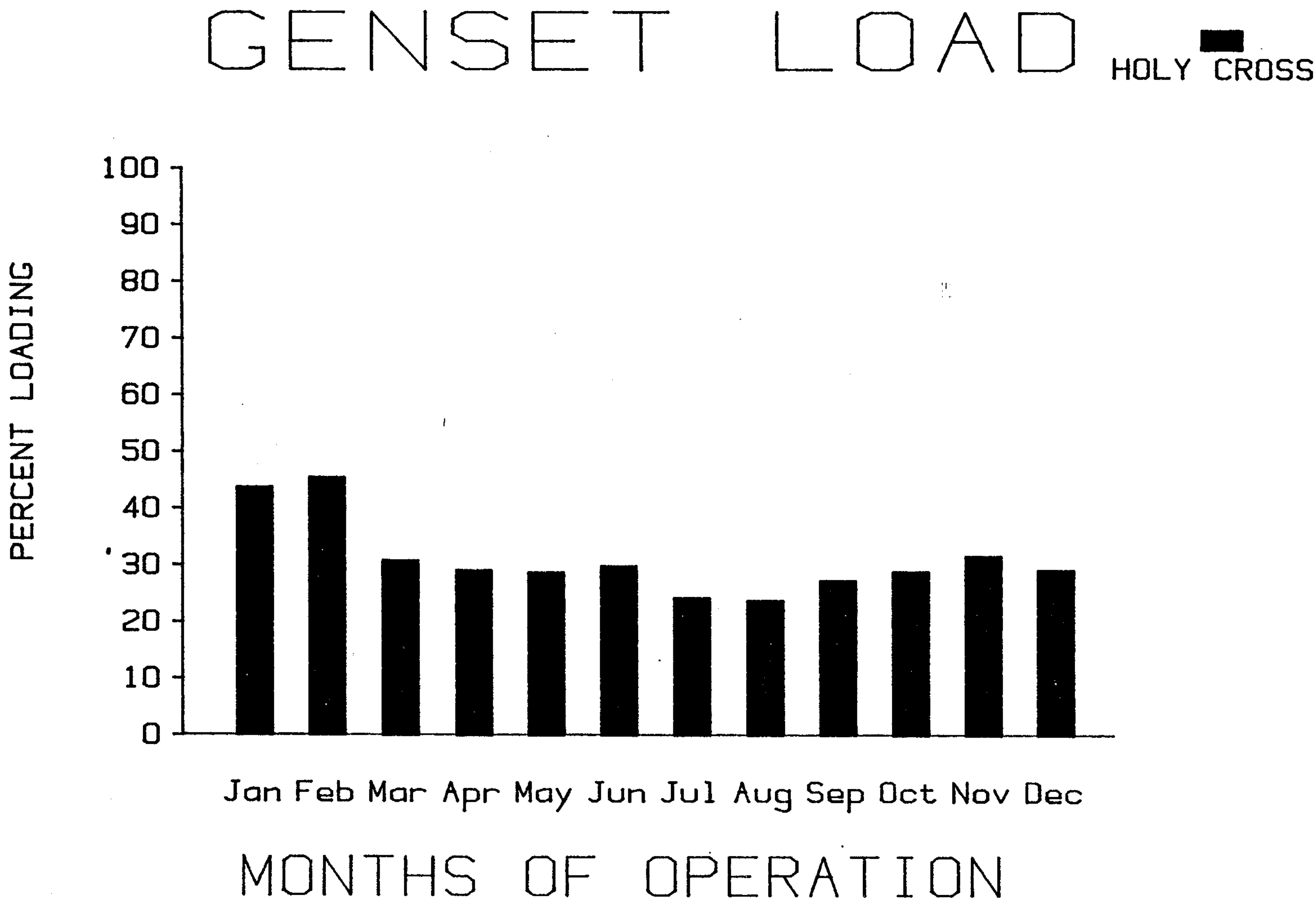
MONTHS OF OPERATION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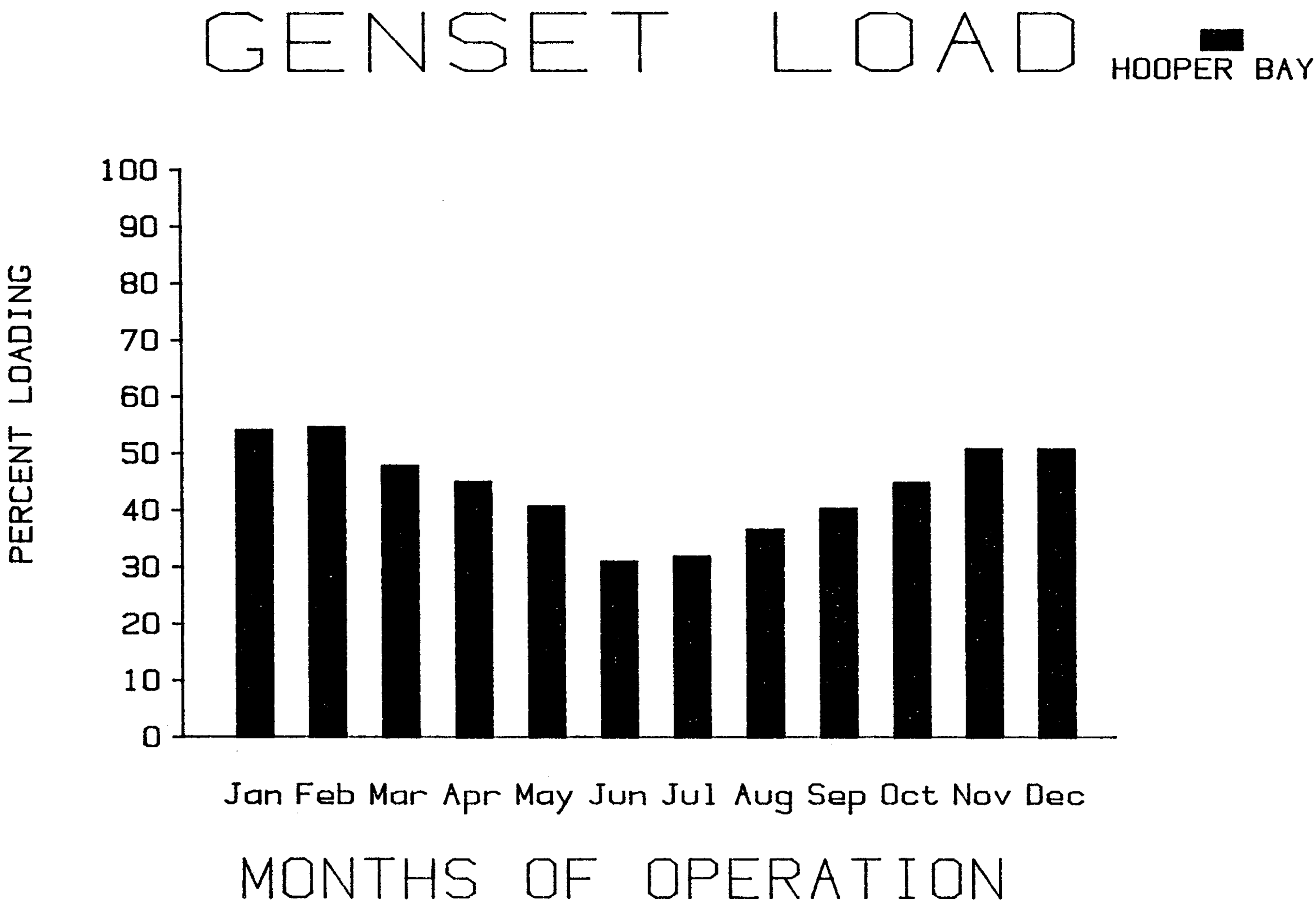
MONTHS OF OPERATION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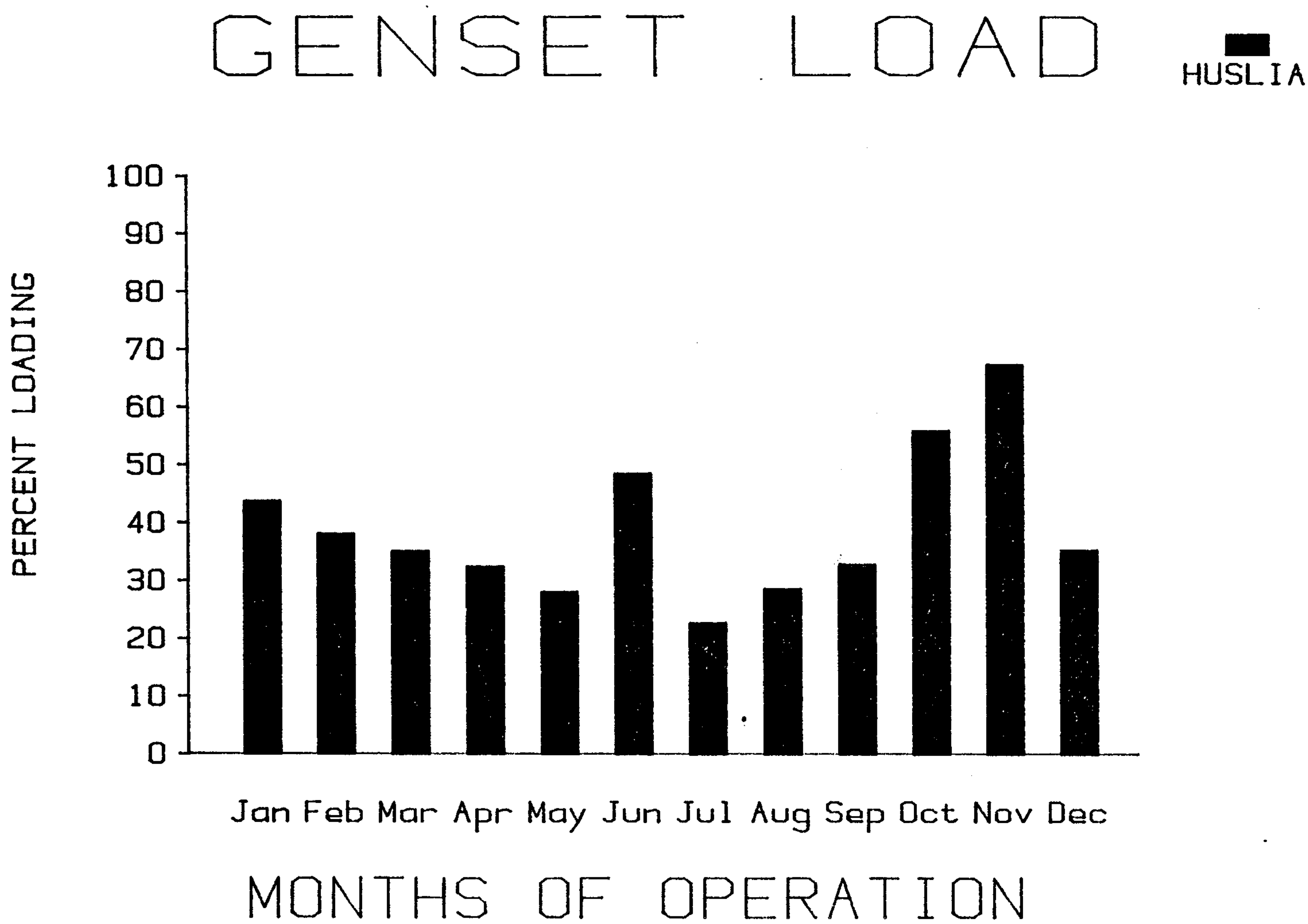
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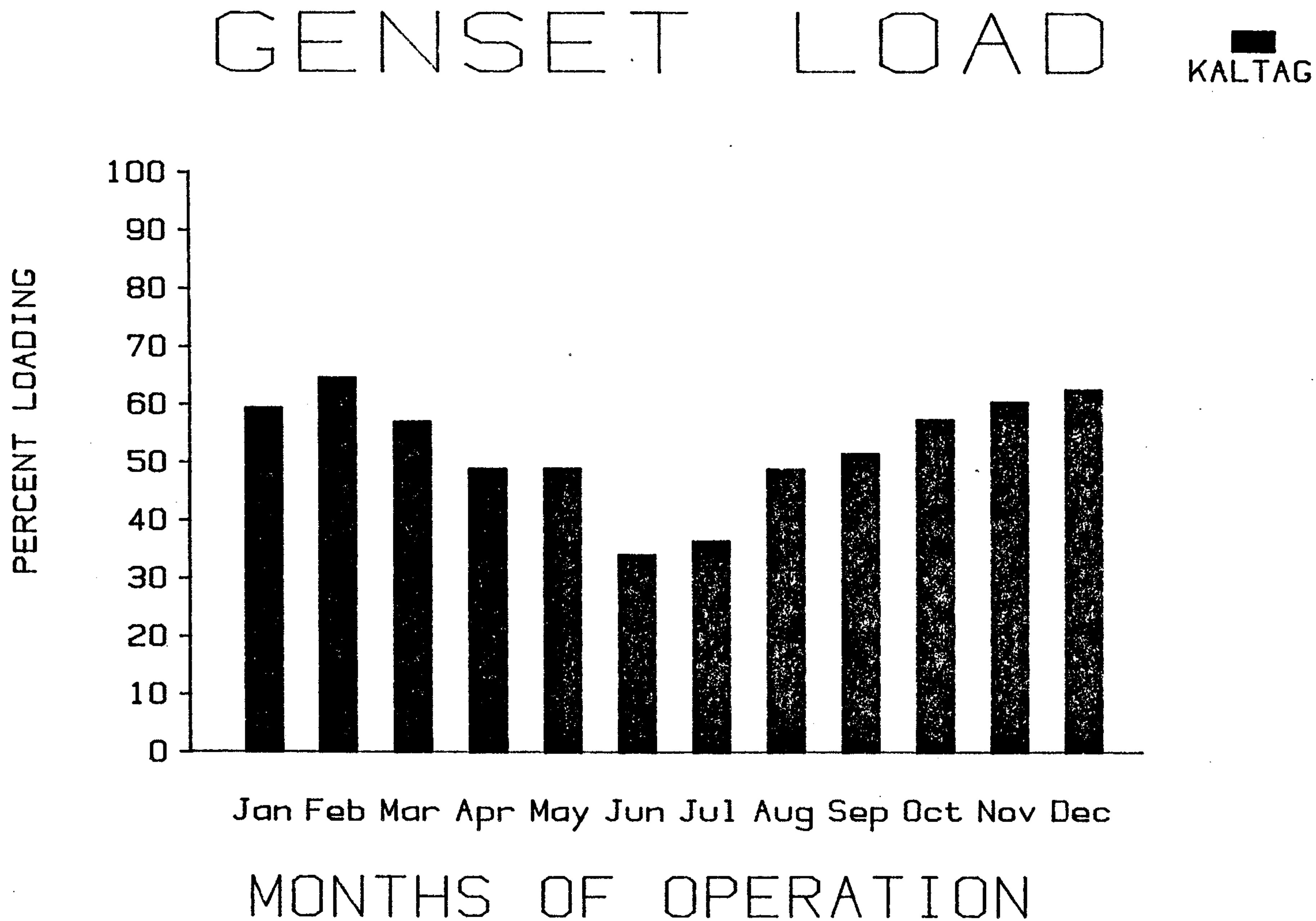
MONTHS OF OPERATION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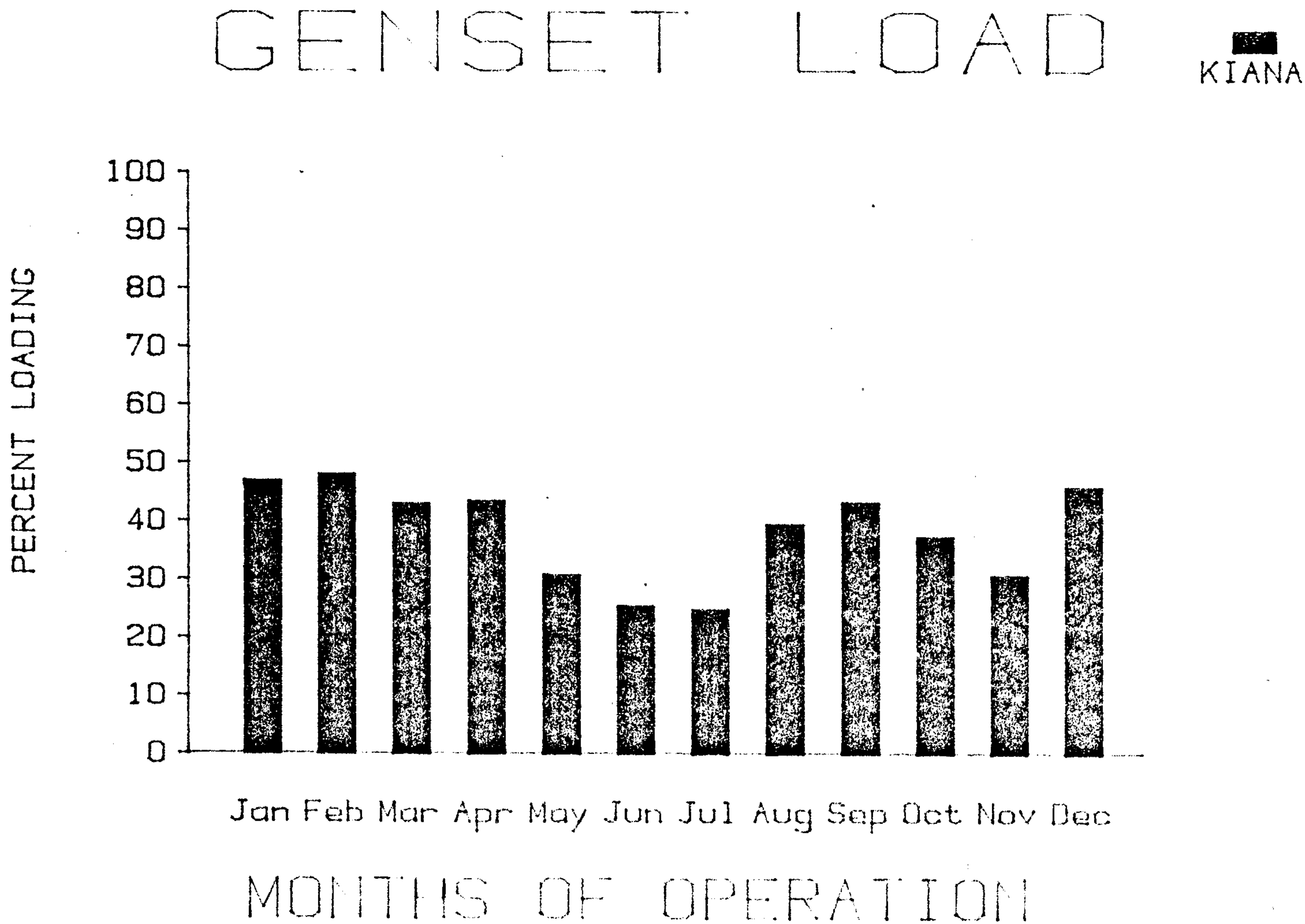
MONTHS OF OPERATION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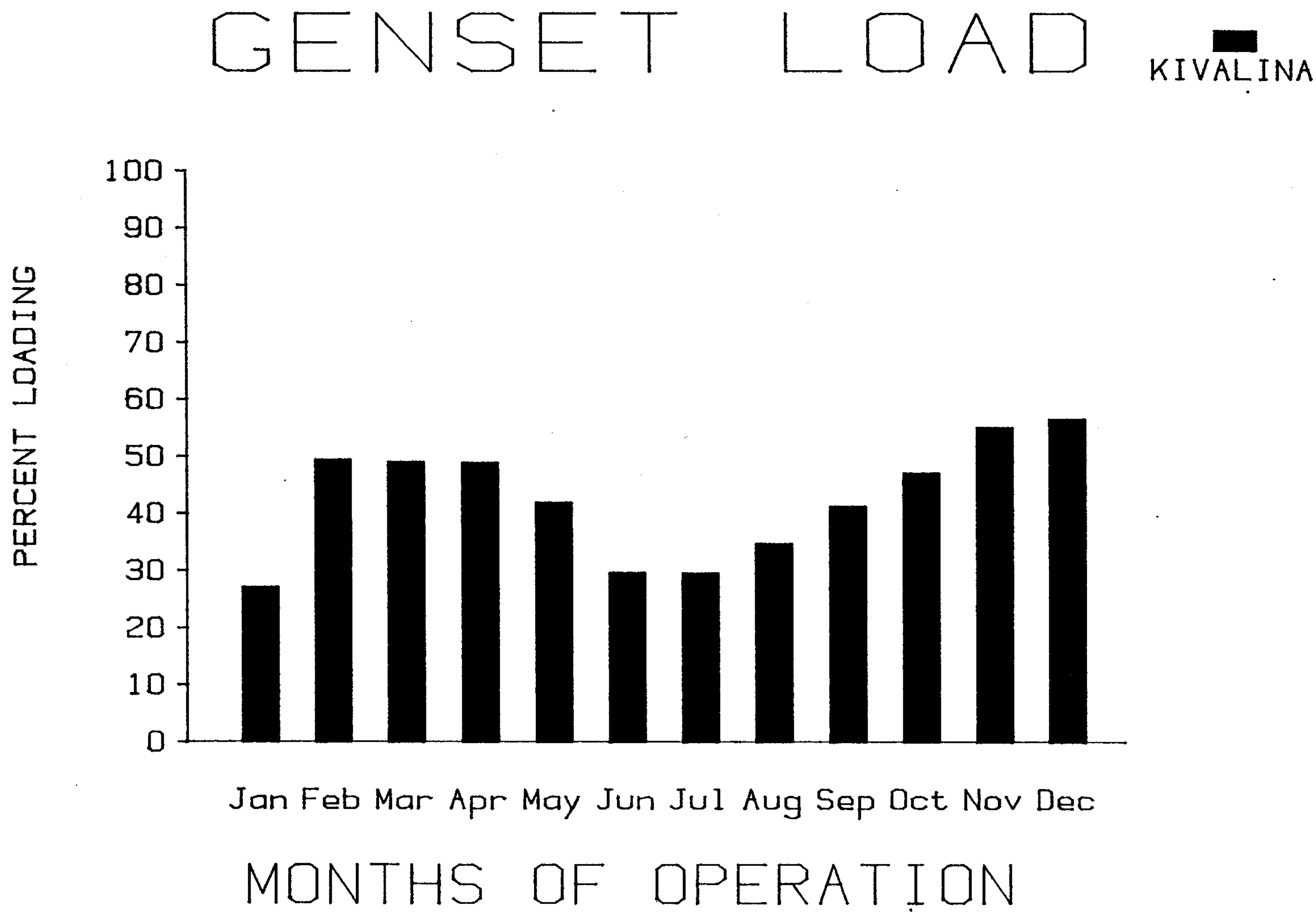
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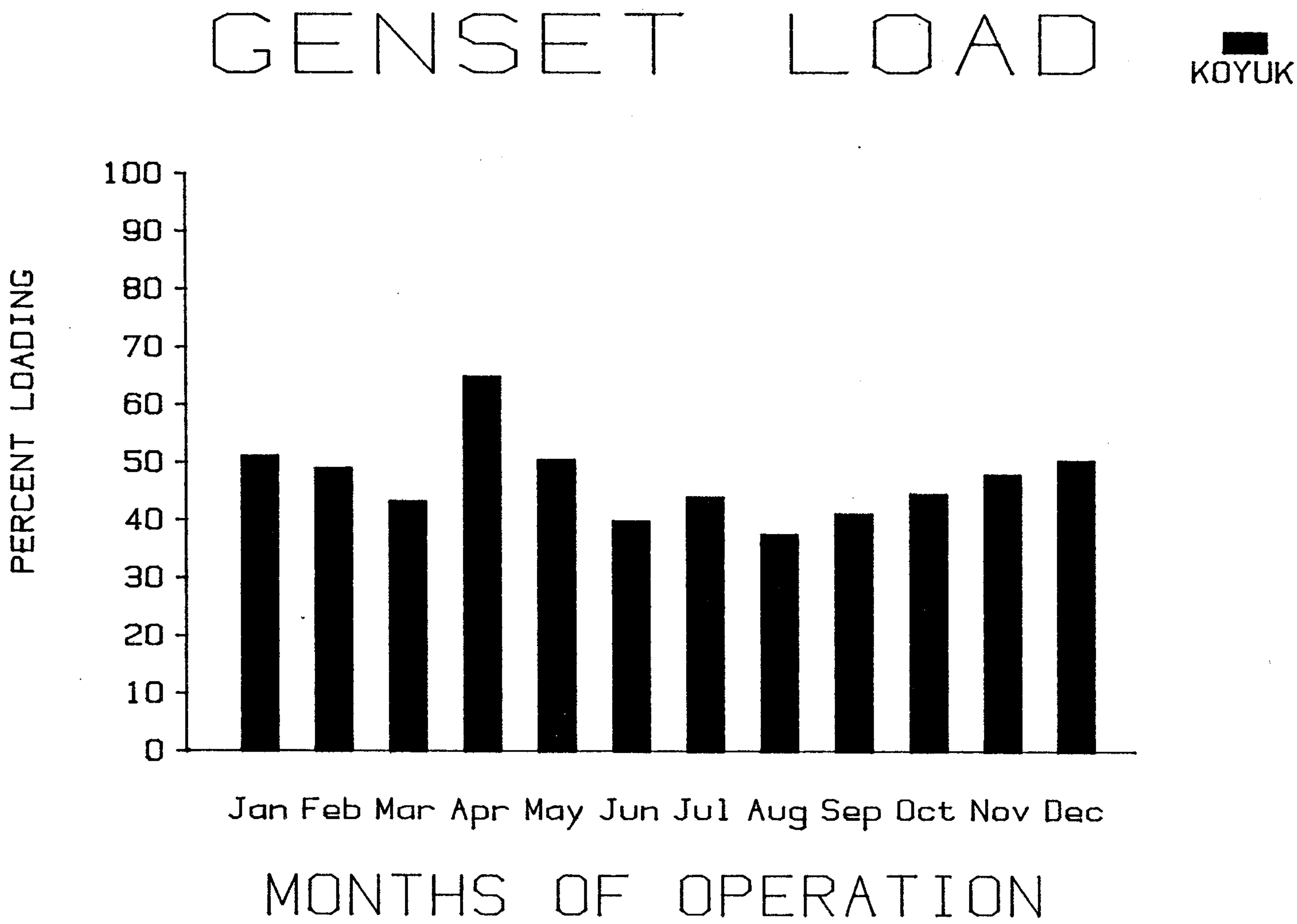
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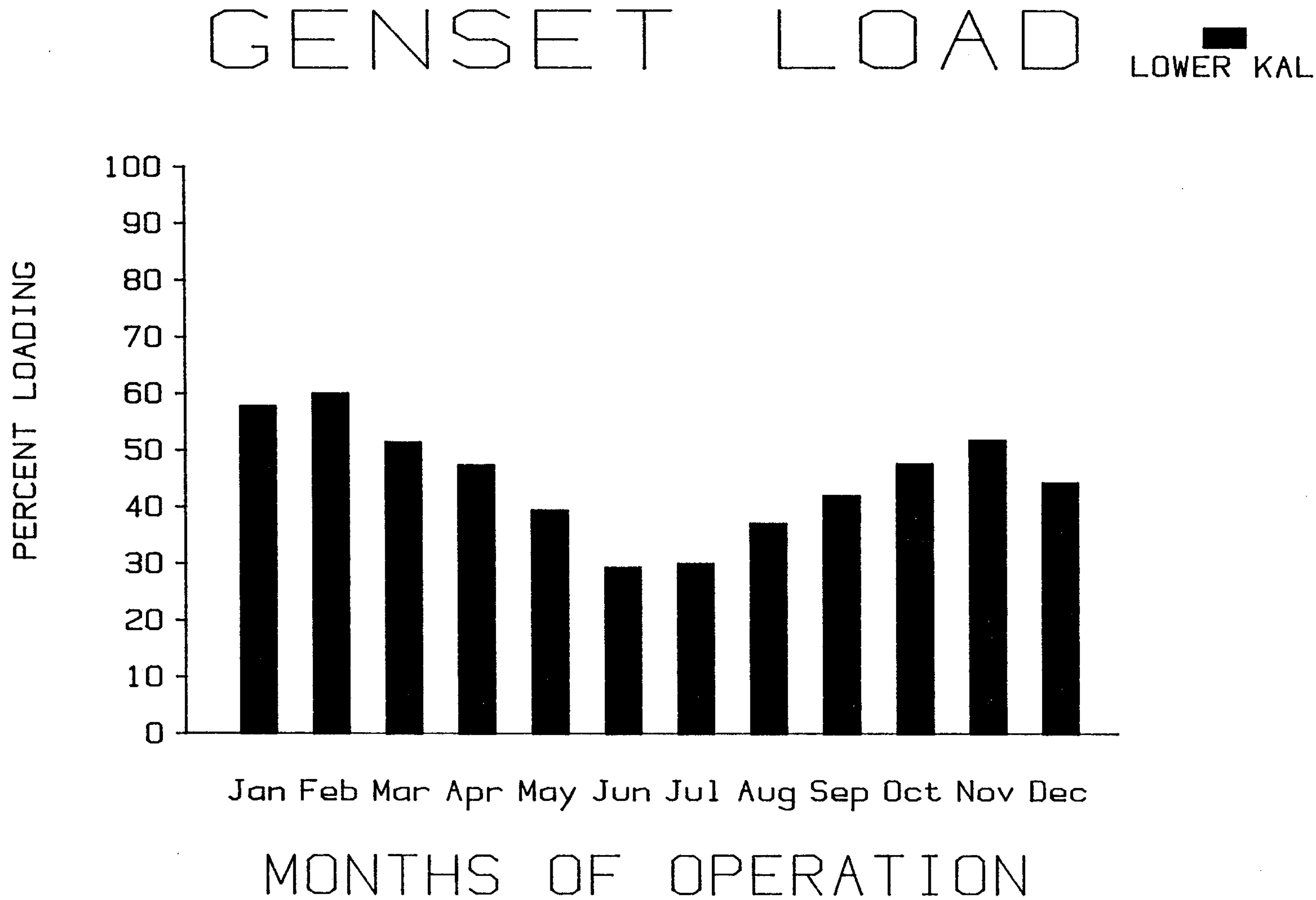
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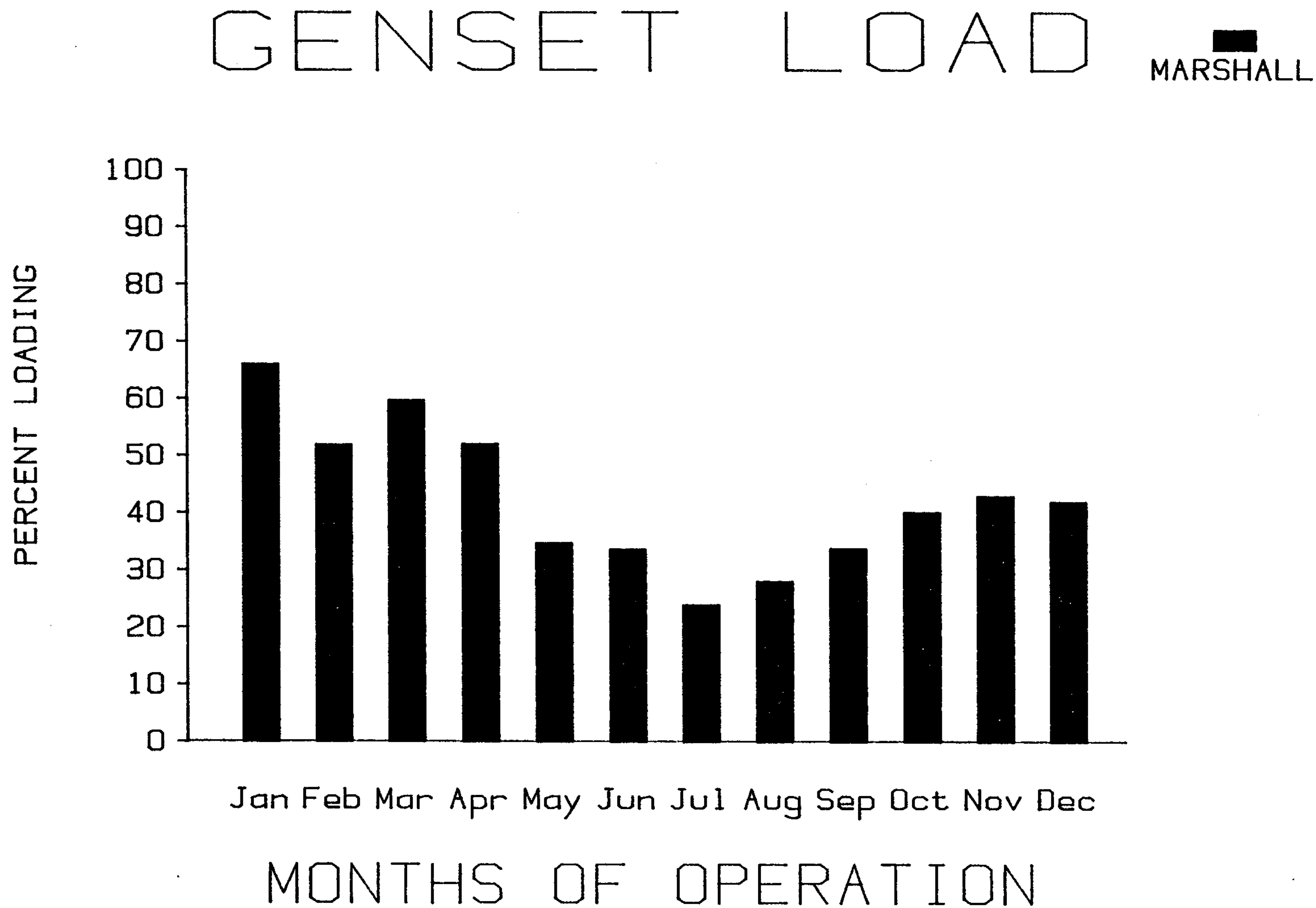
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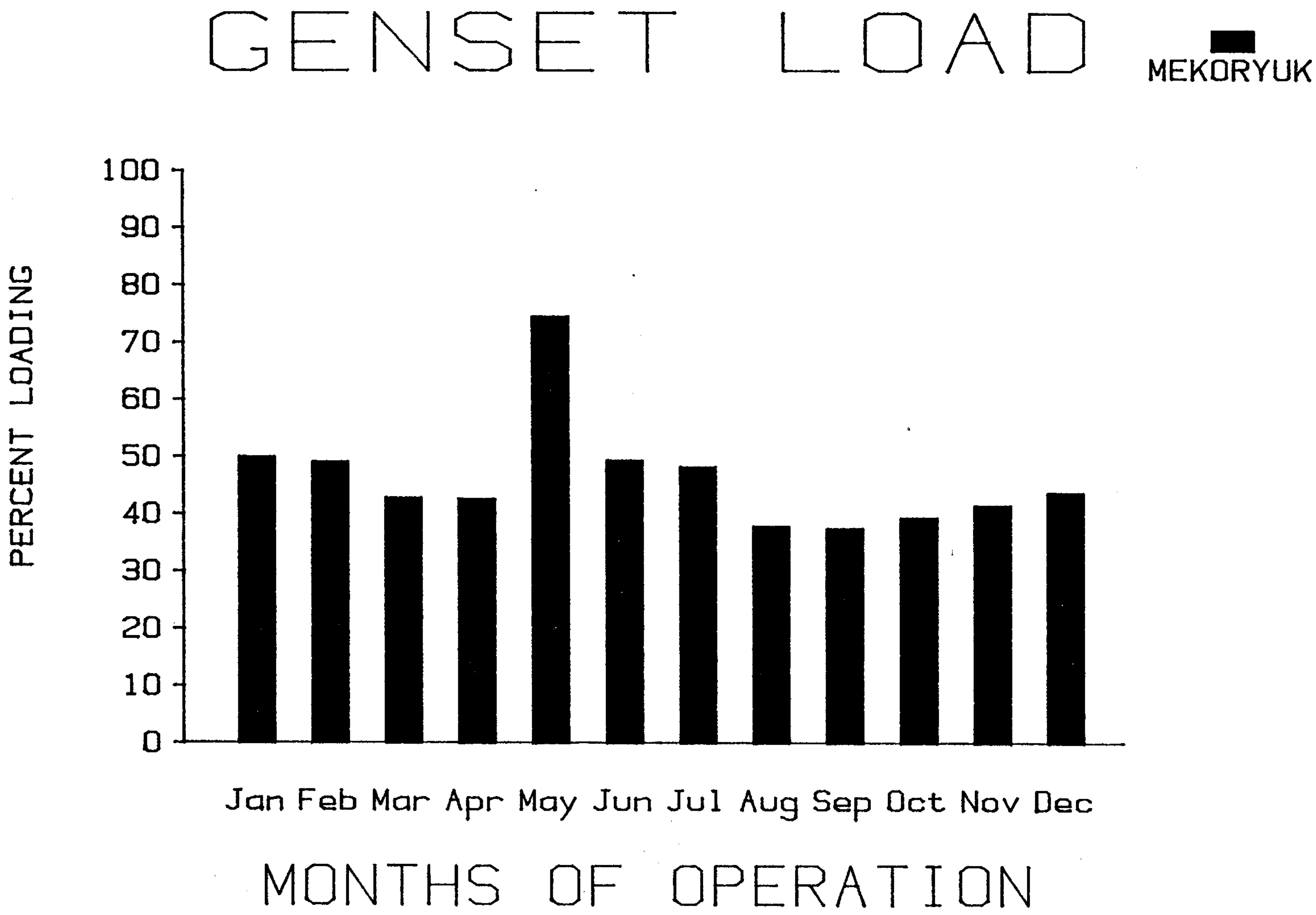
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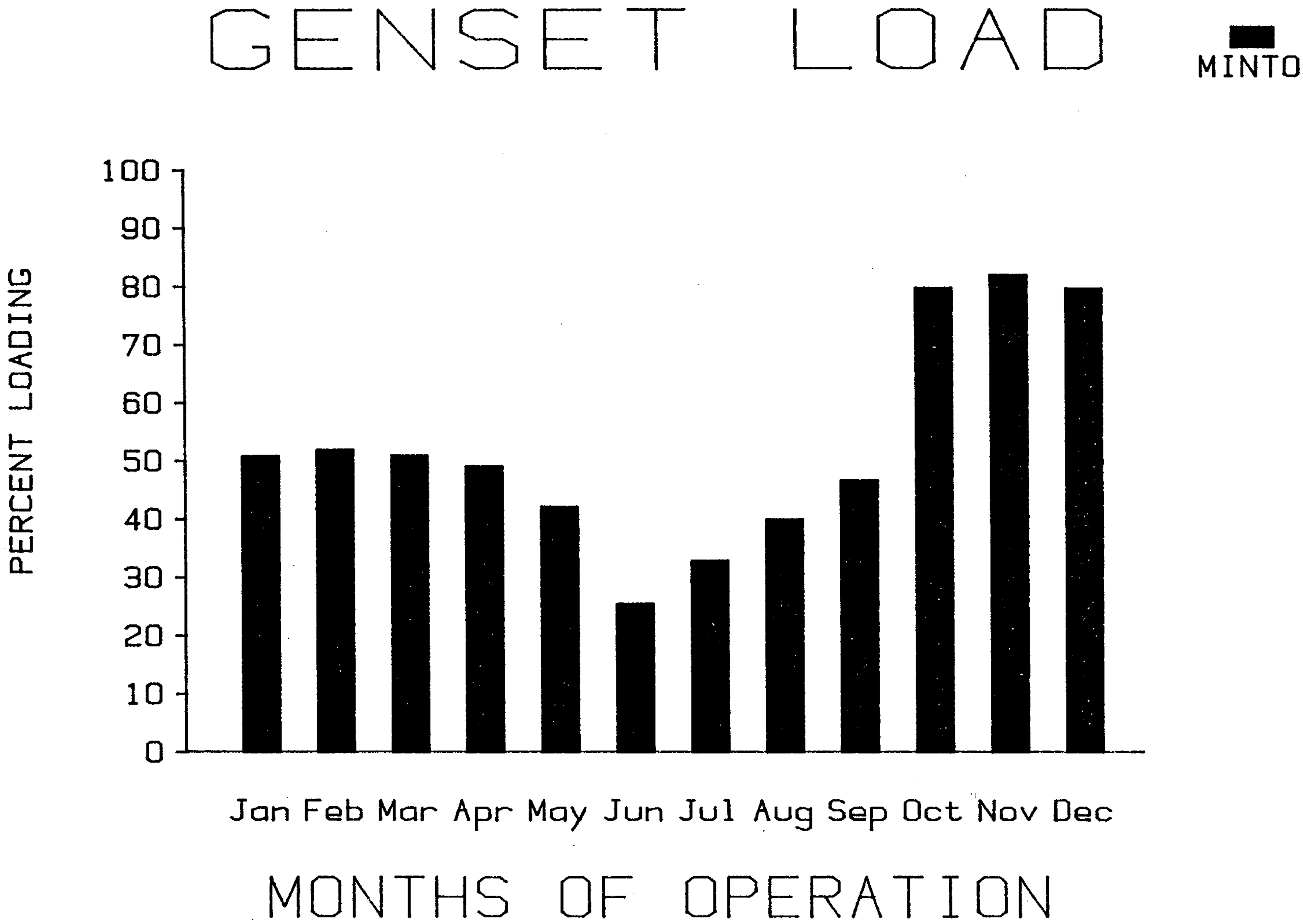
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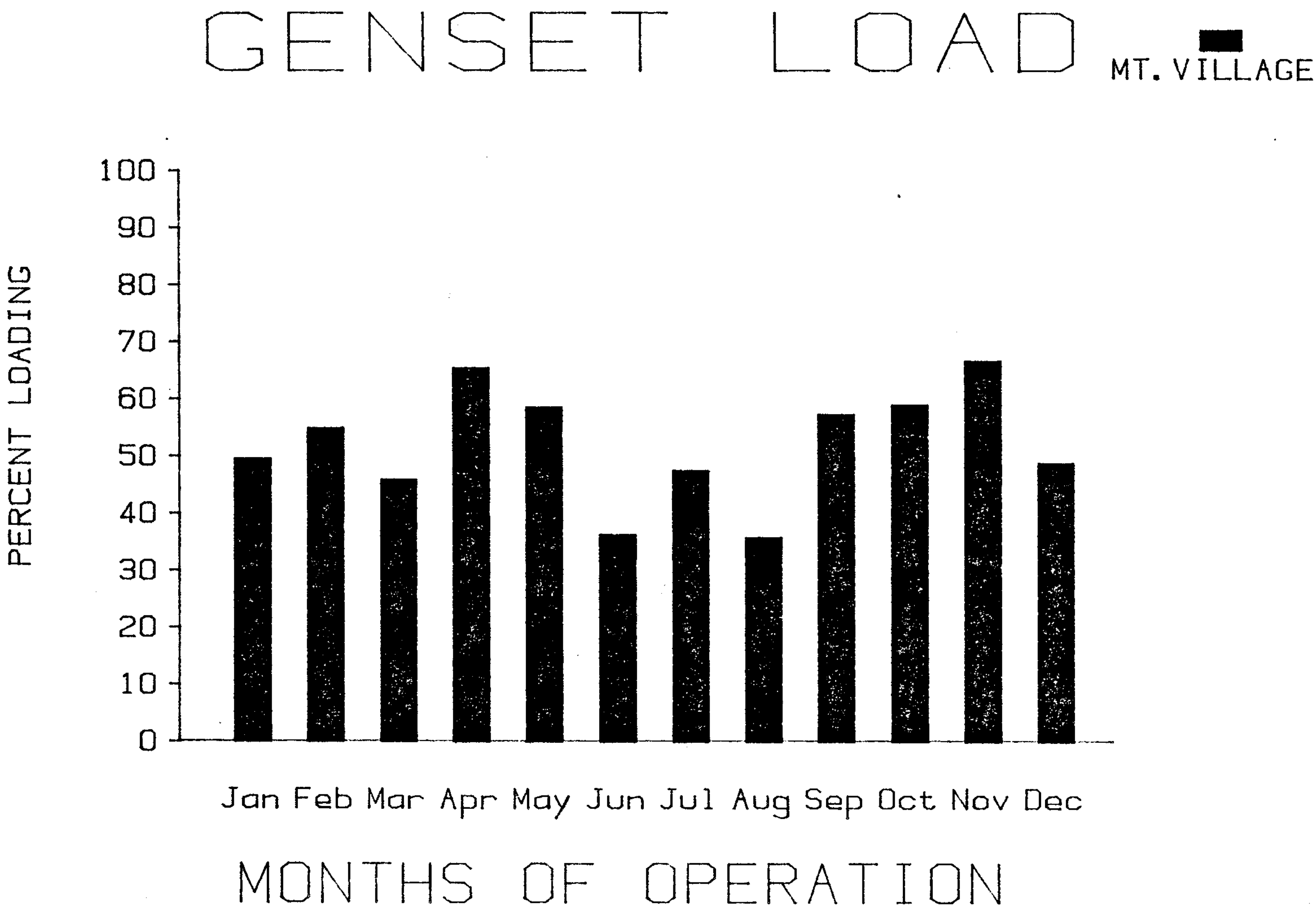
MONTHS OF OPERATION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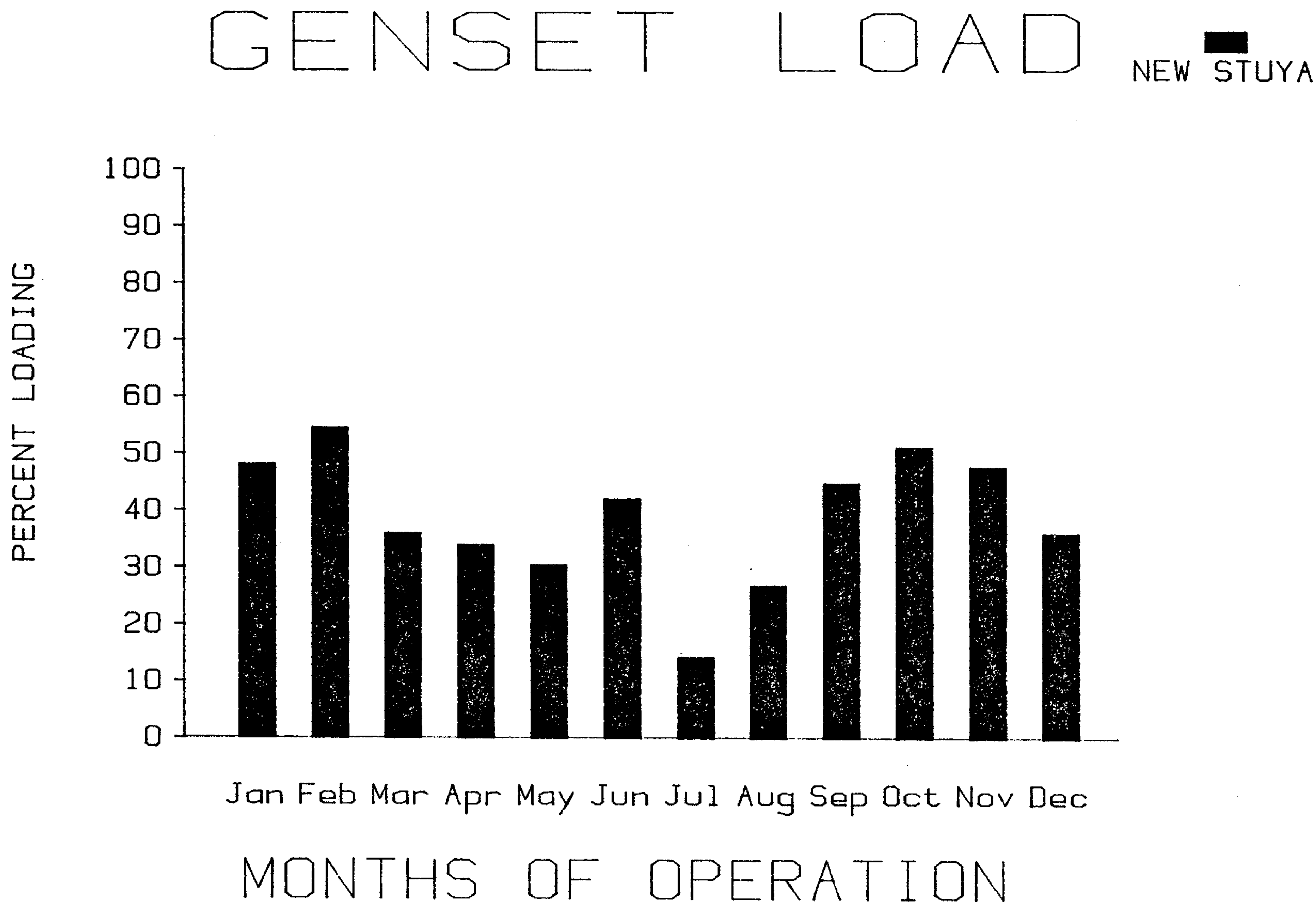
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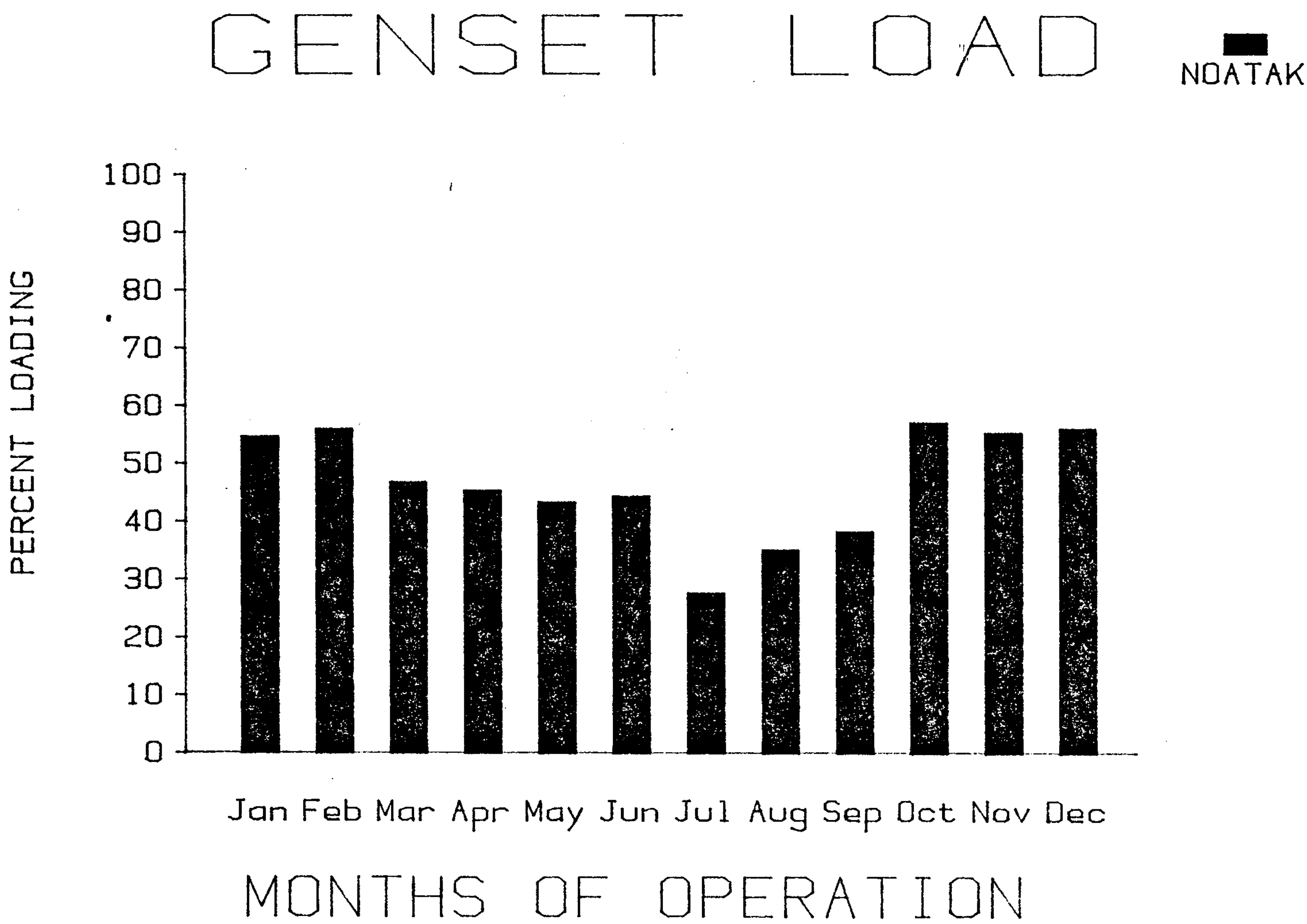
MONTHS OF OPERATION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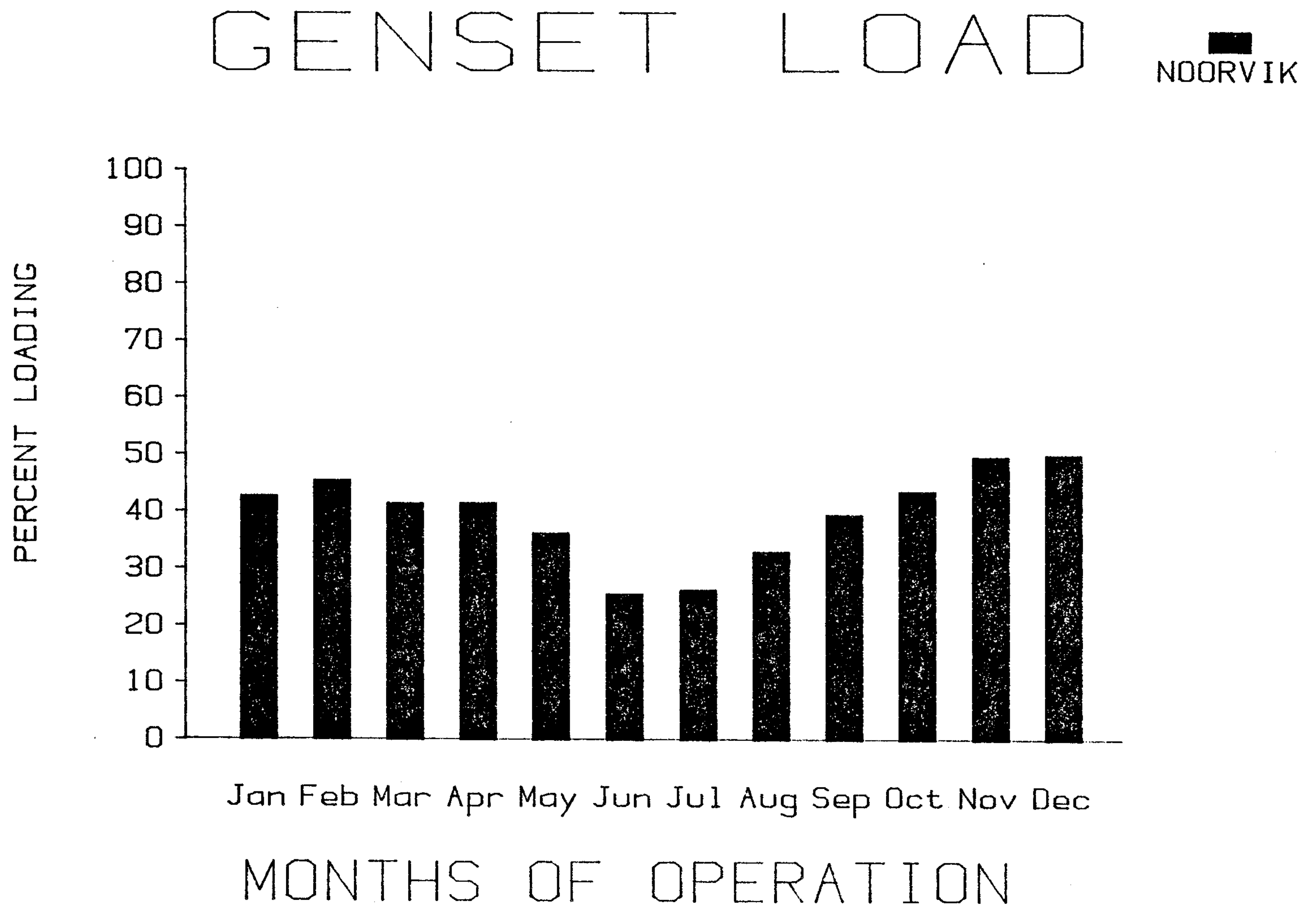
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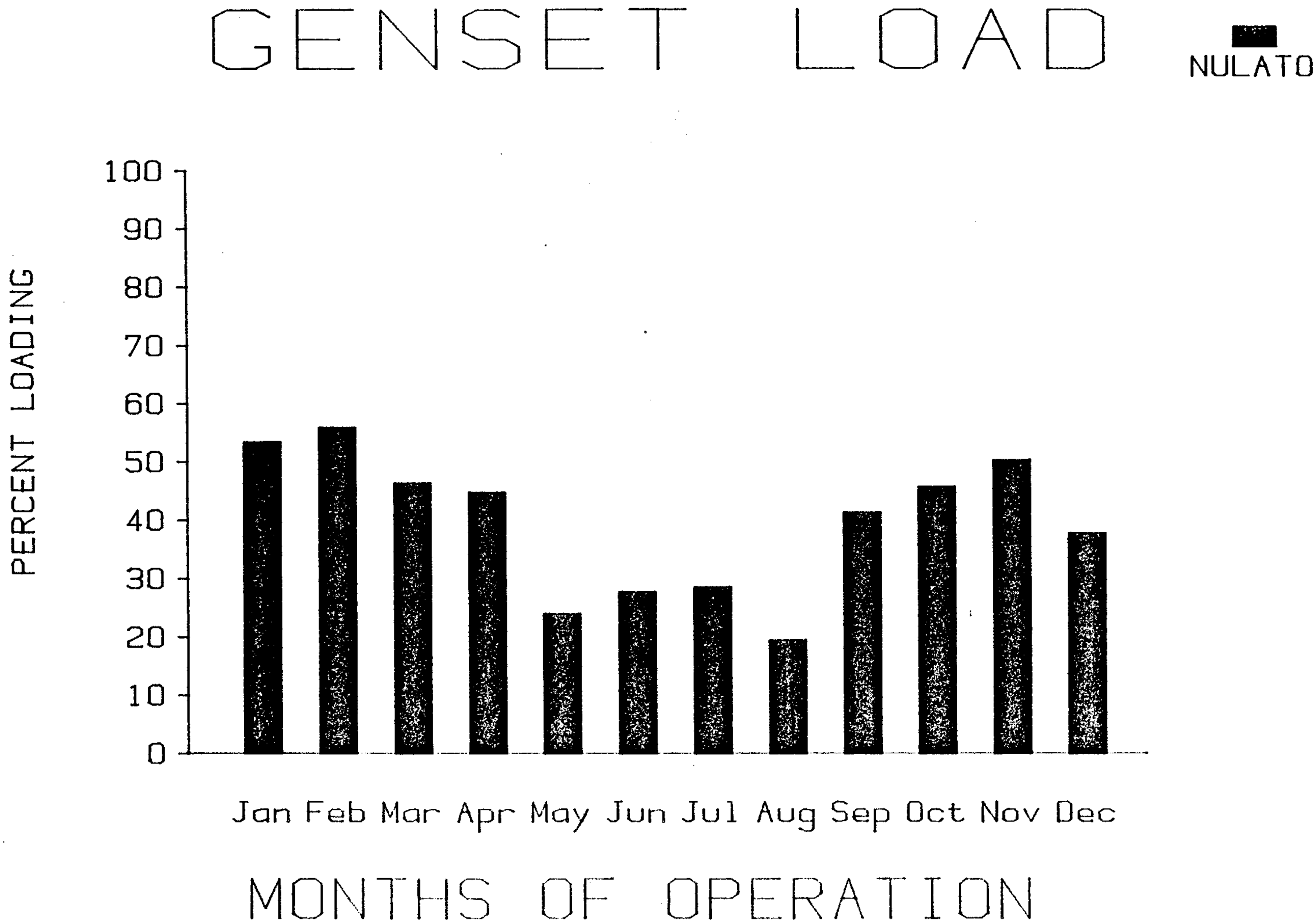
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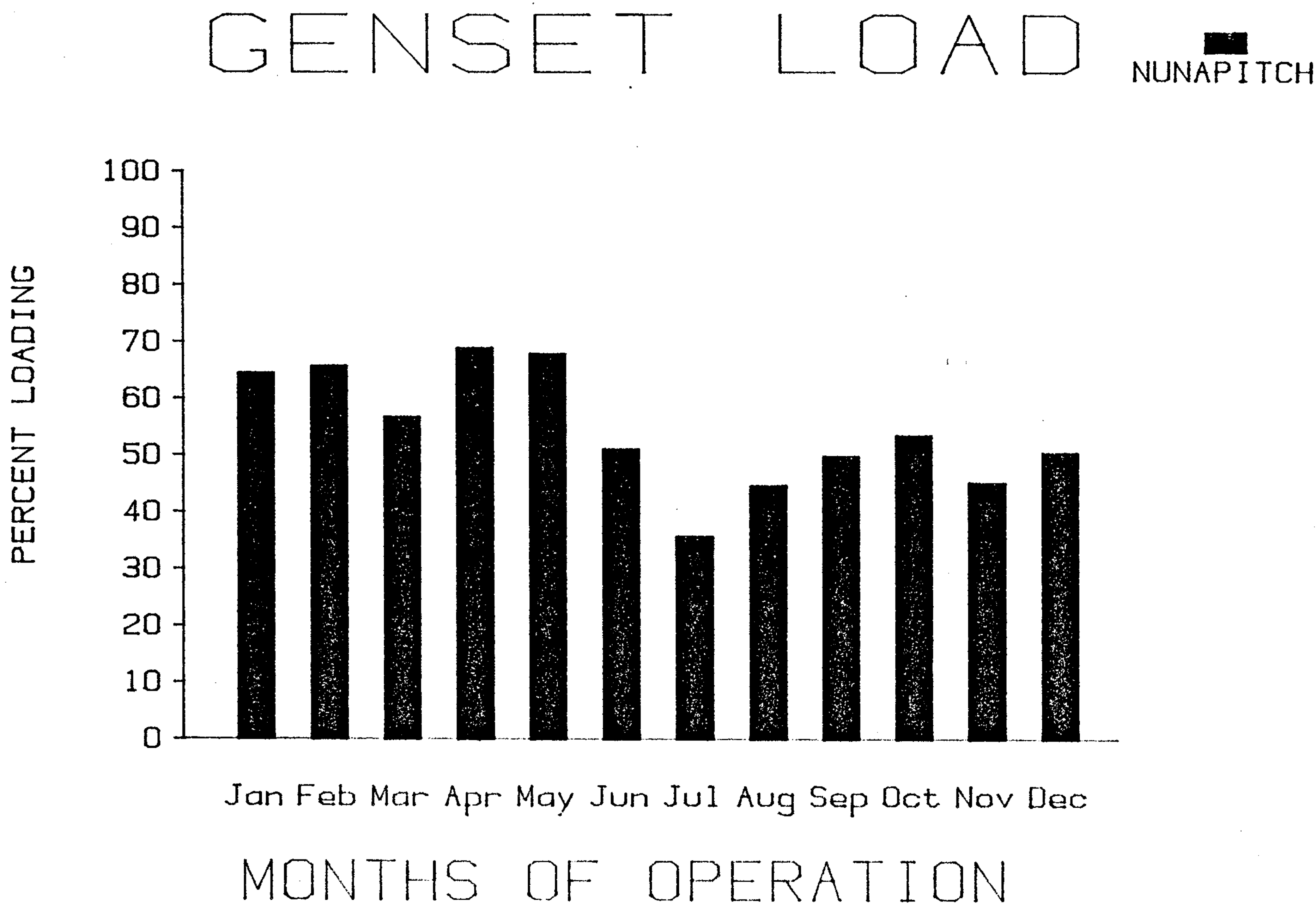
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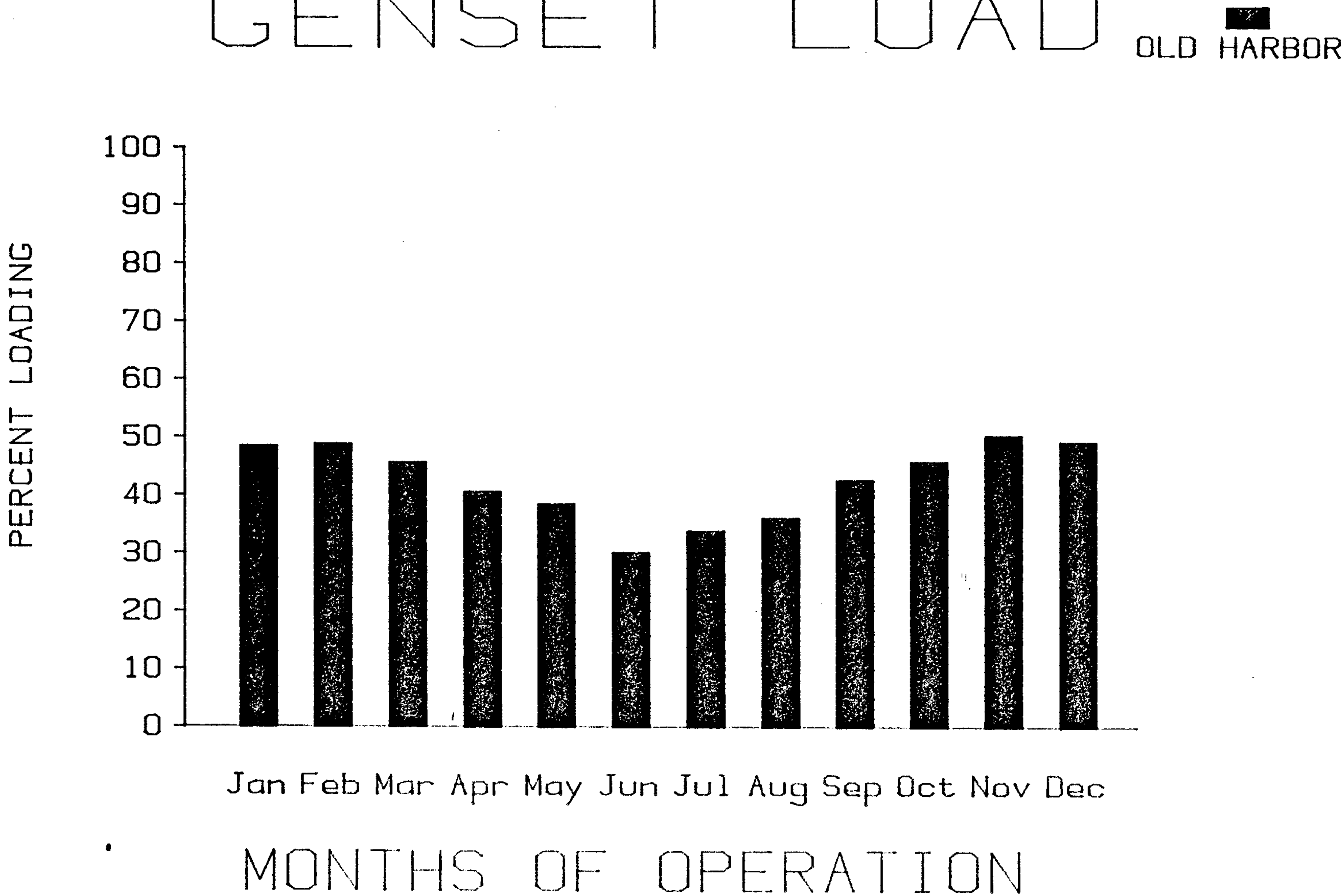
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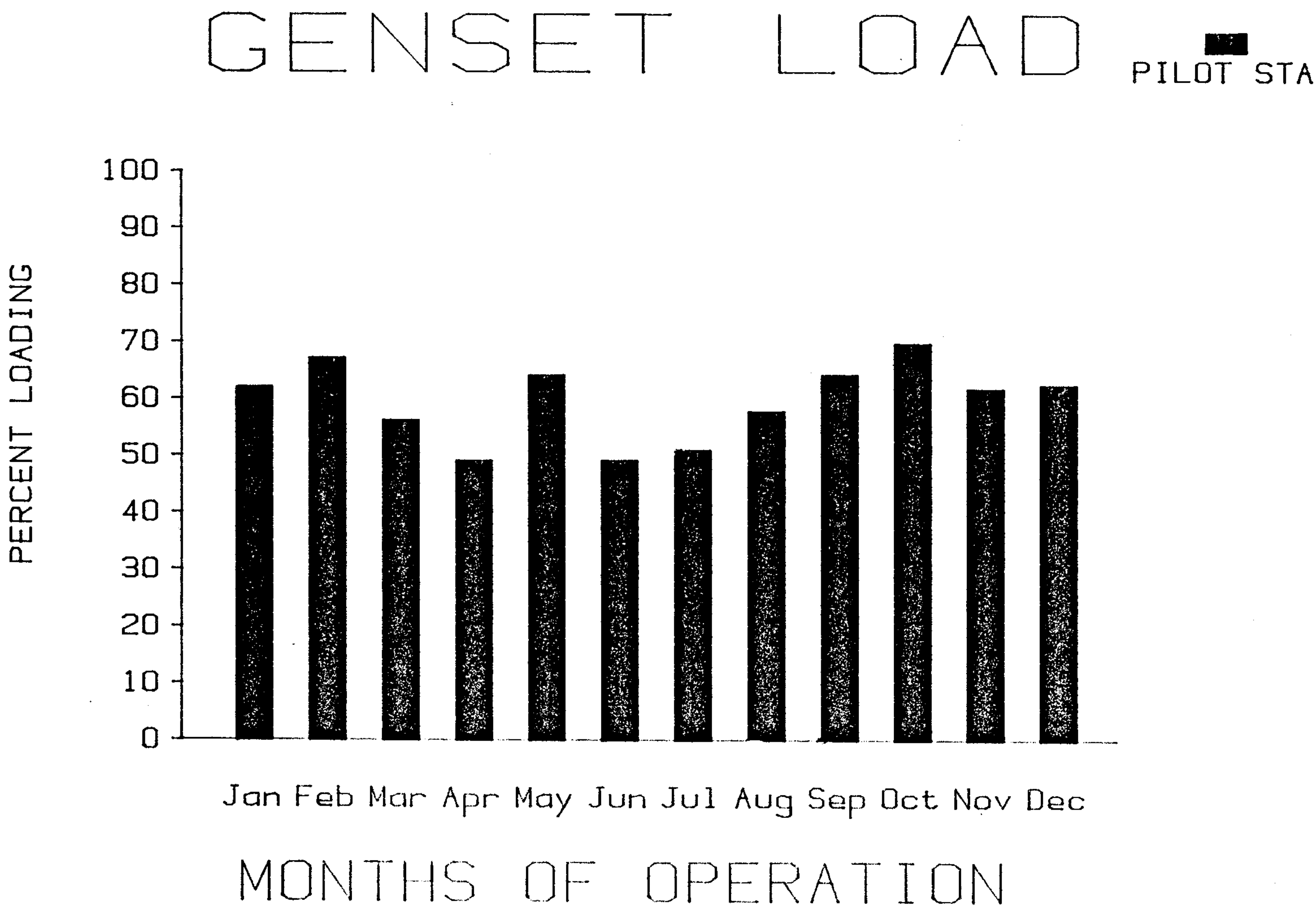
MONTHS OF OPERATION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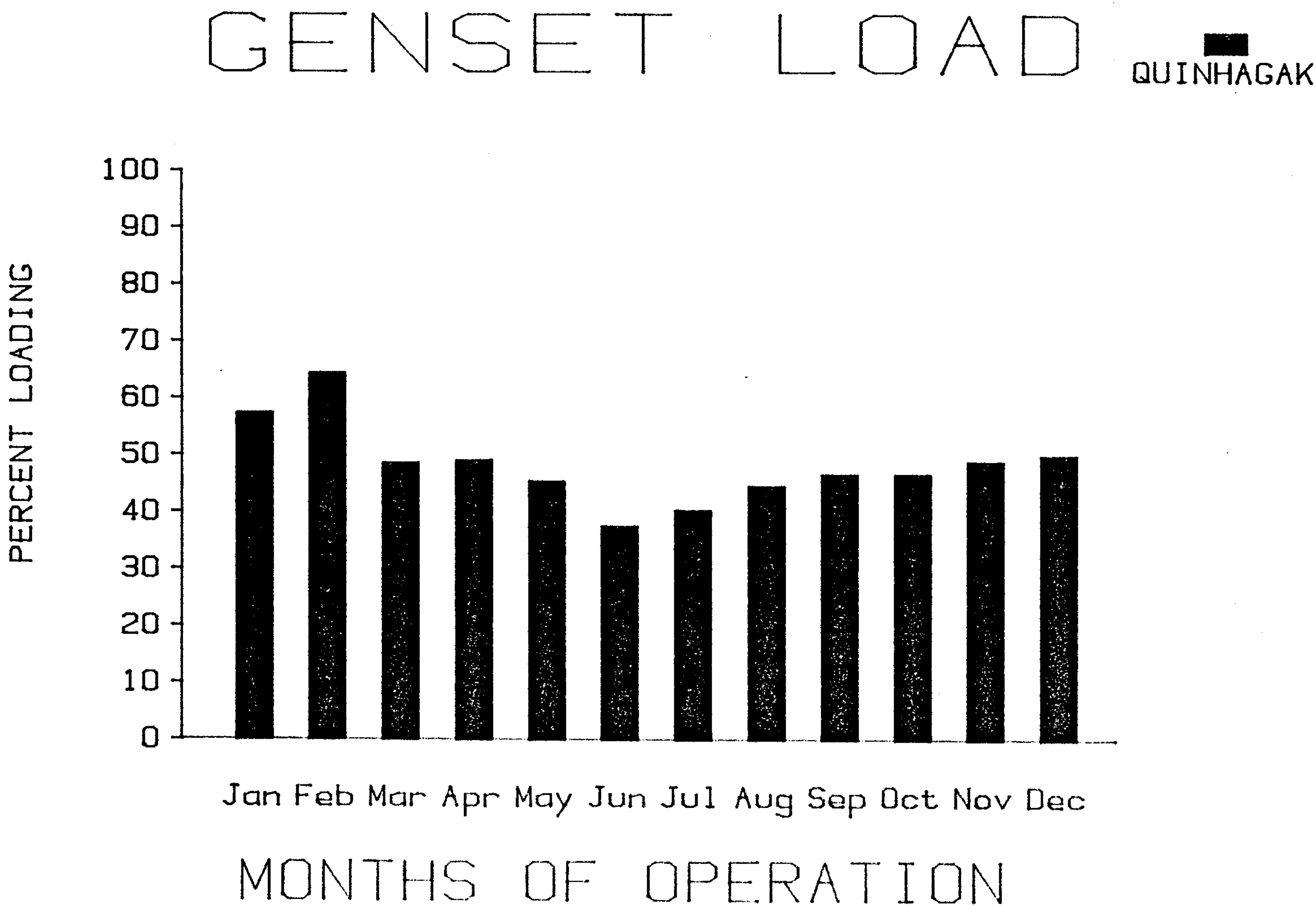
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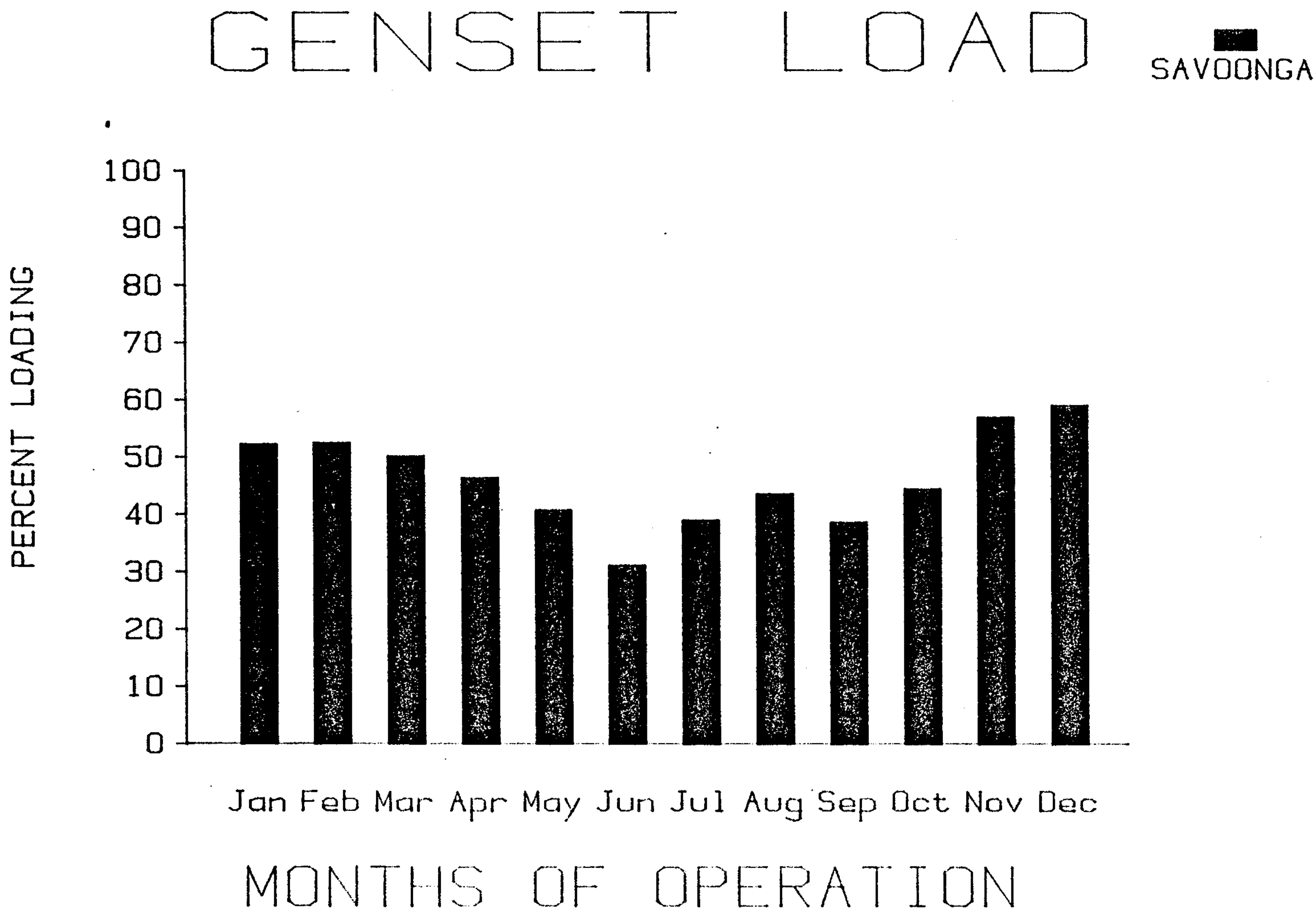
MONTHS OF OPERATION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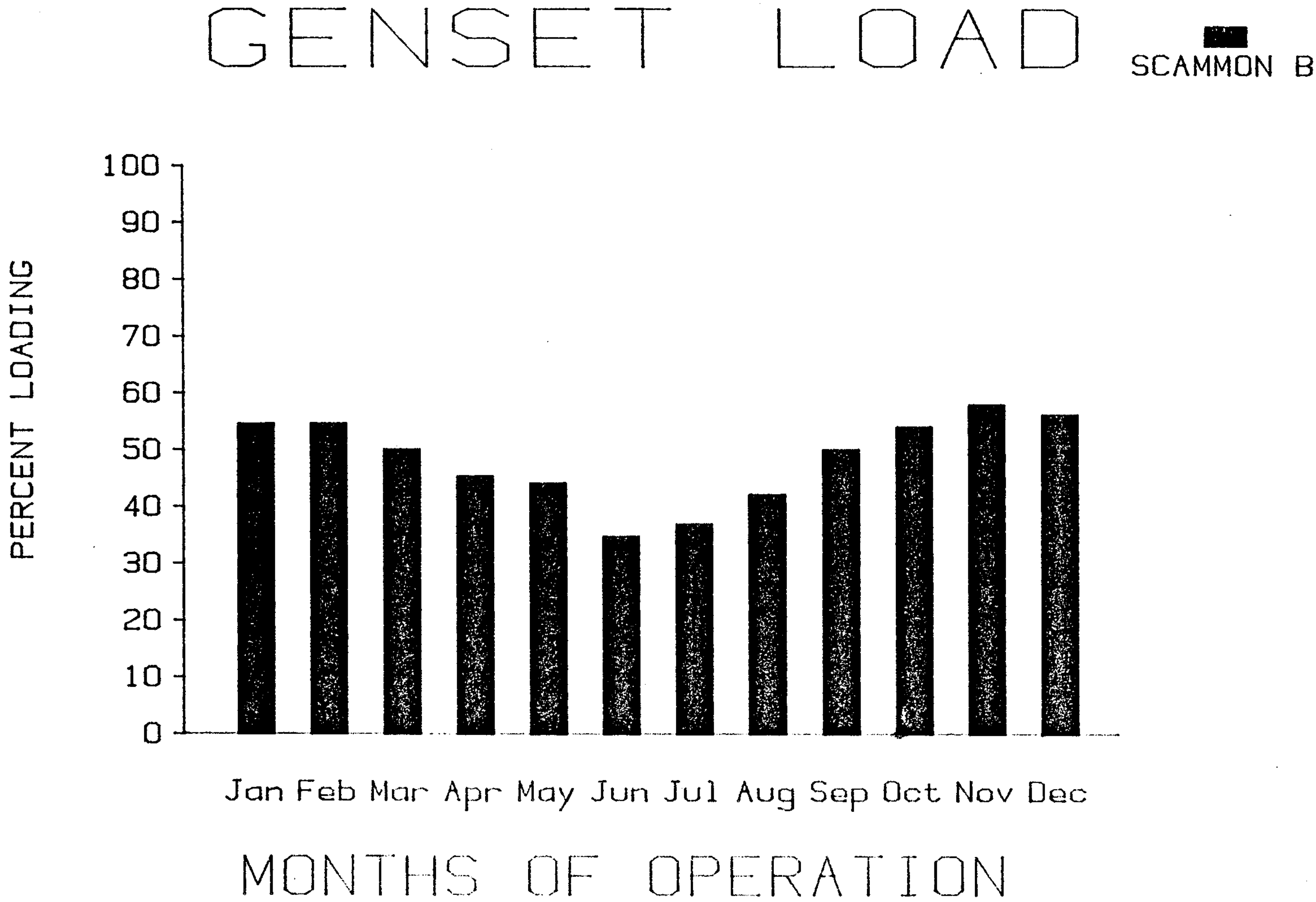
MONTHS OF OPERATION



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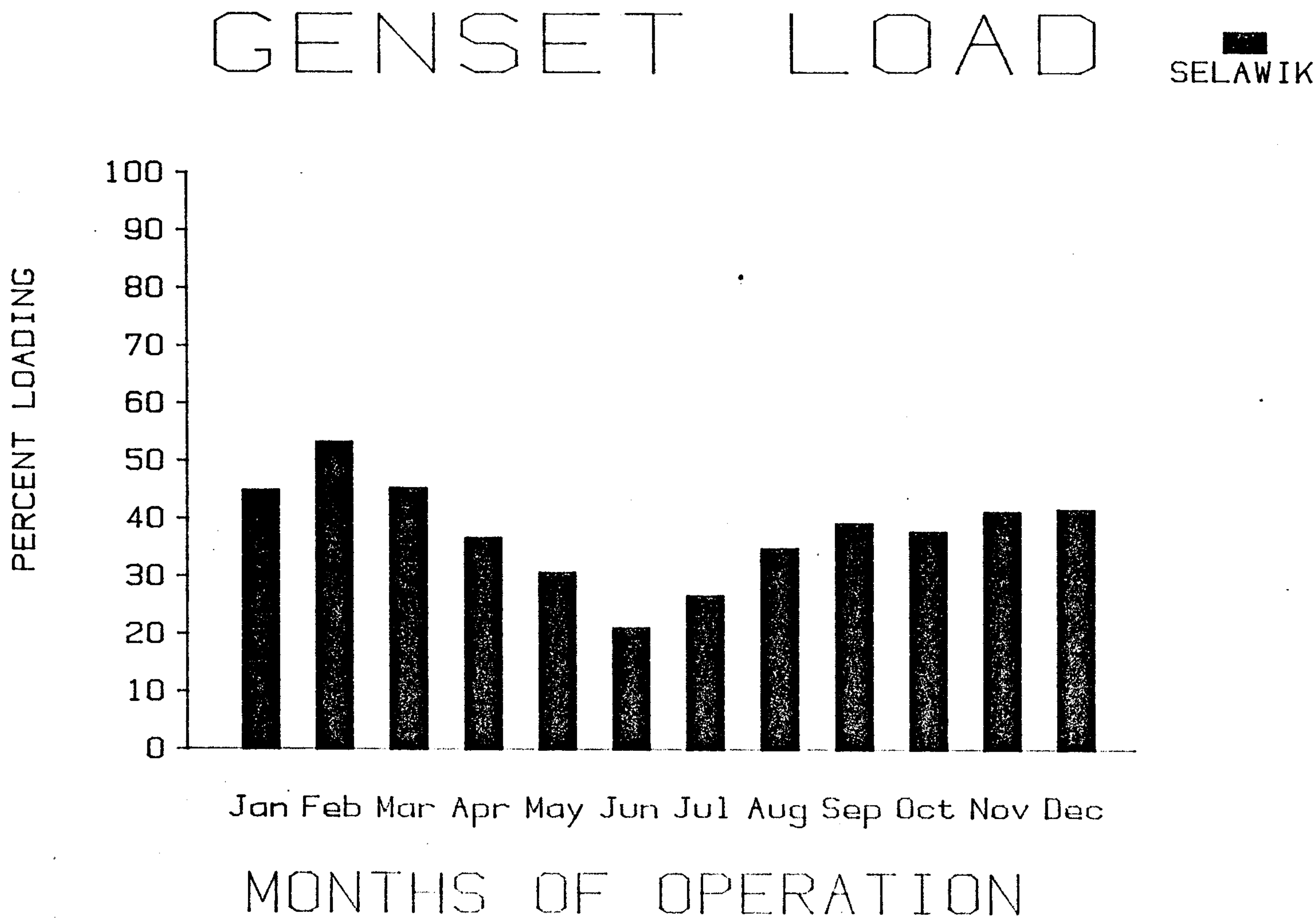

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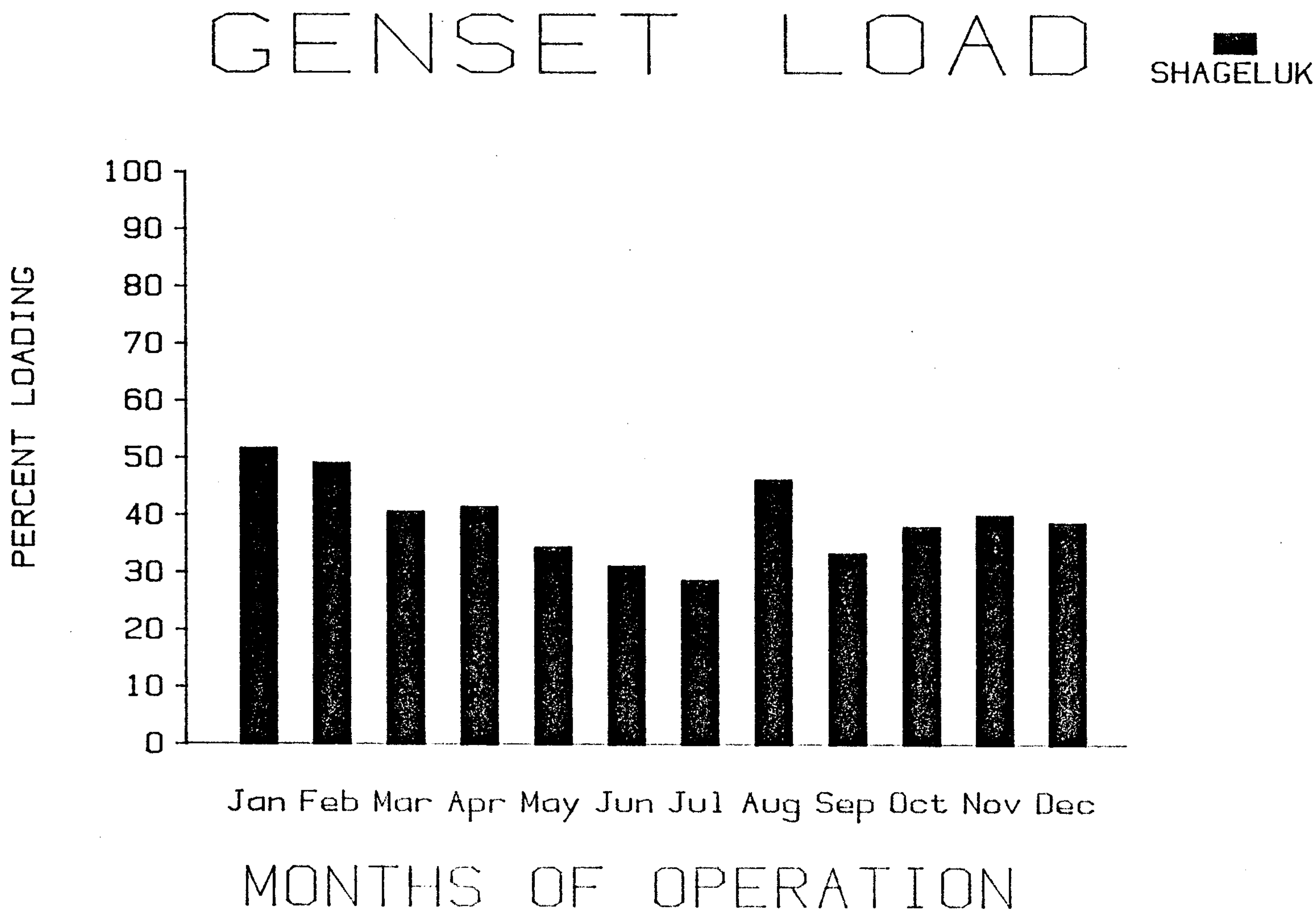
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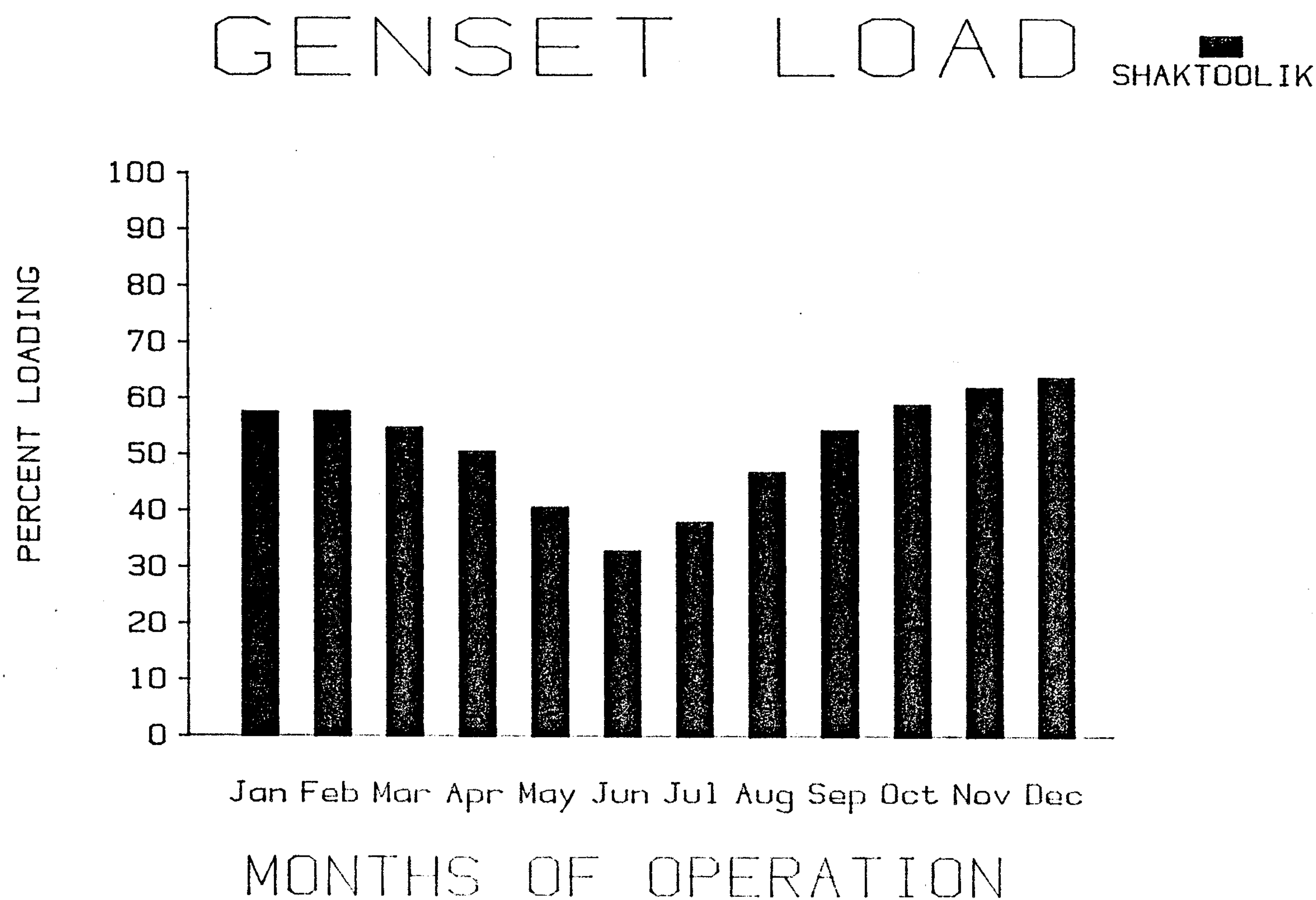
MONTHS OF OPERATION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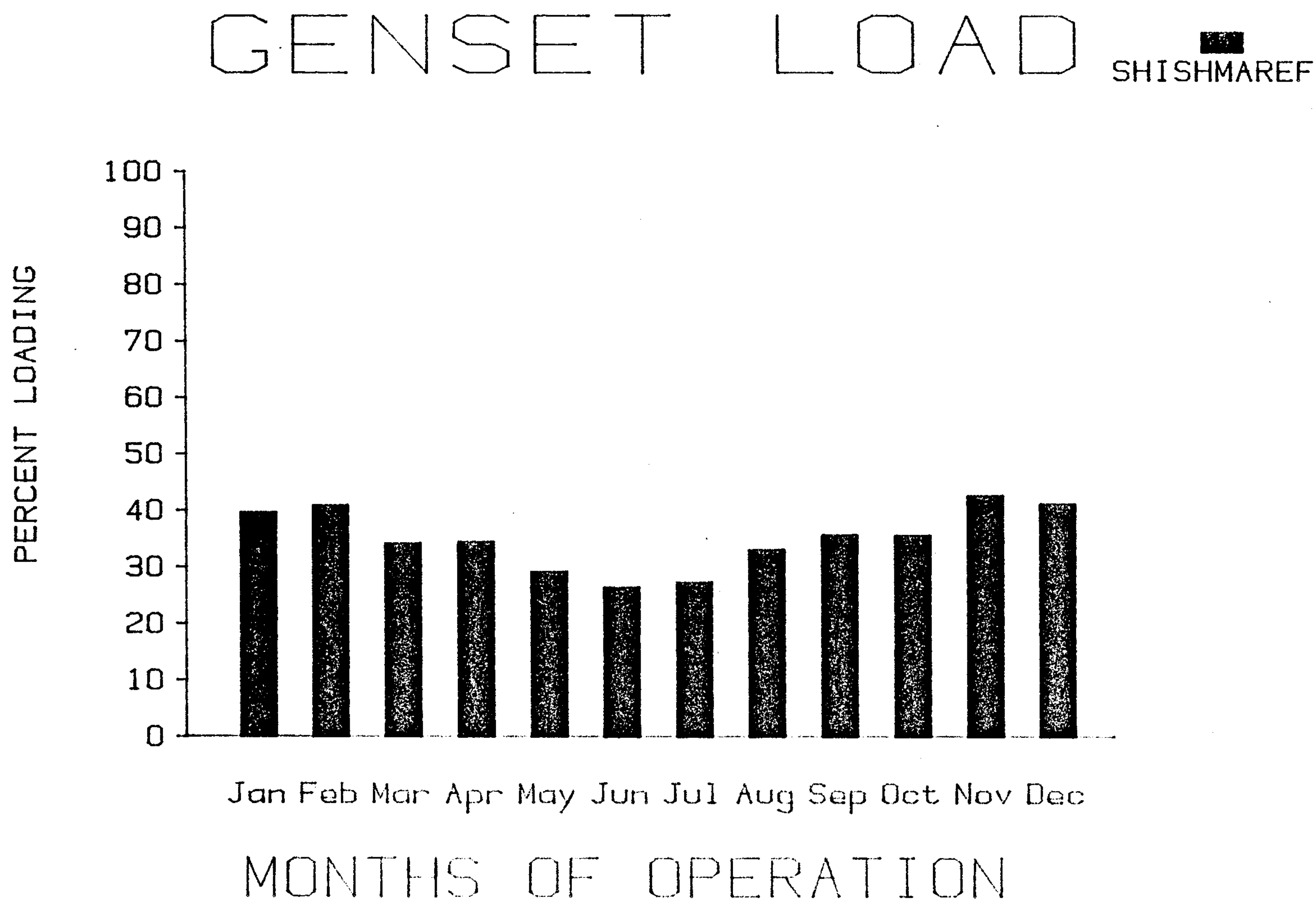
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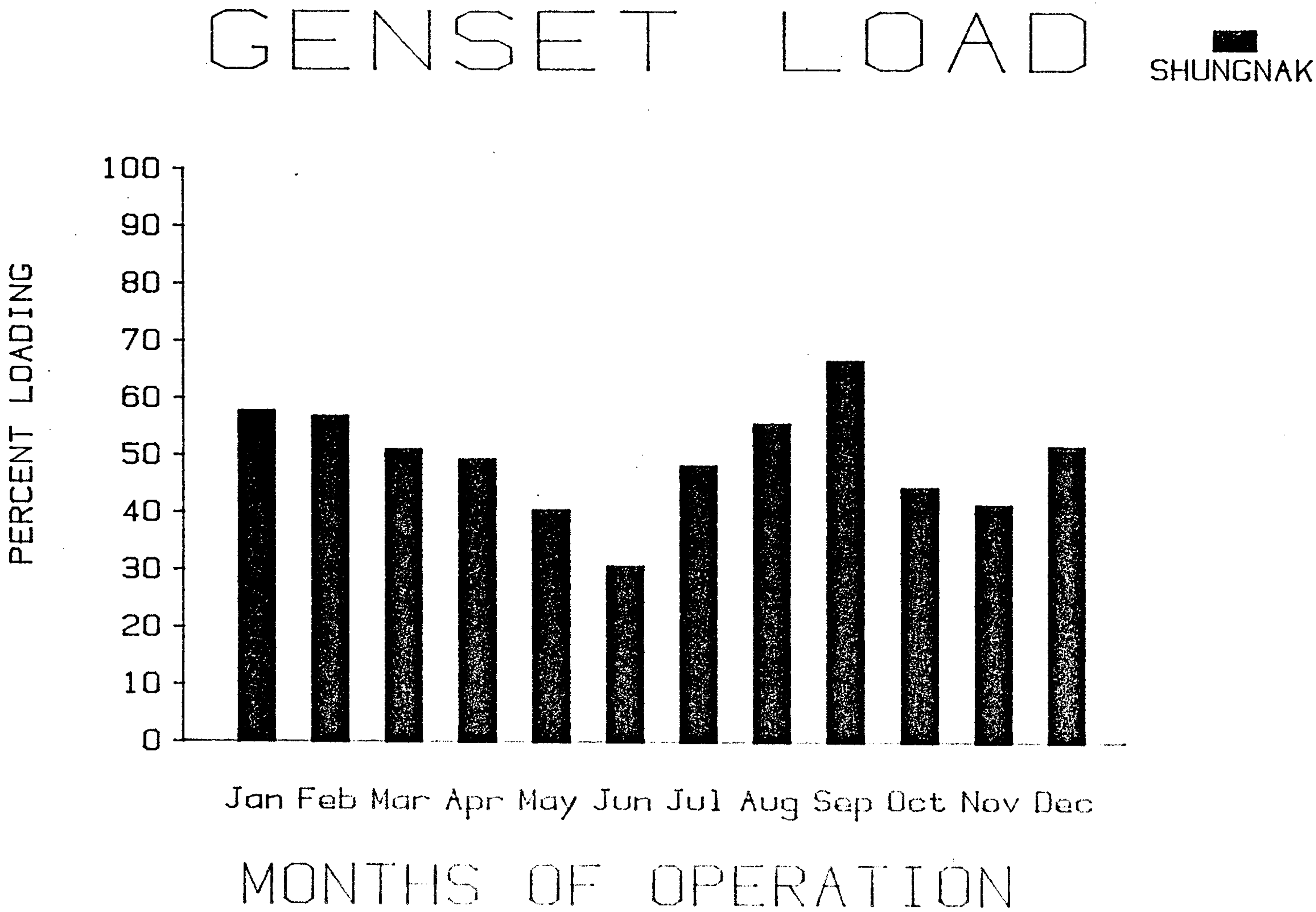
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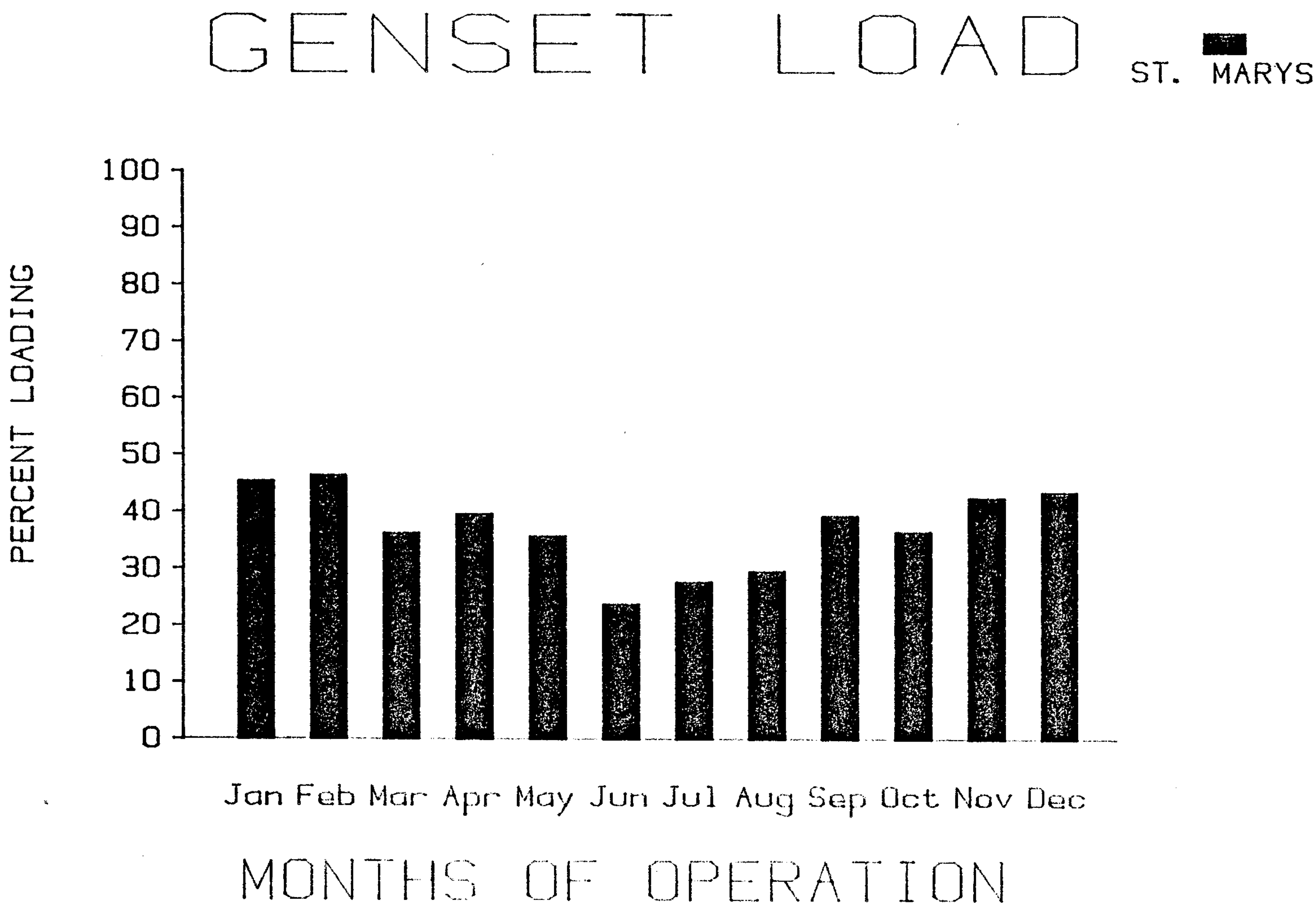
MONTHS OF OPERATION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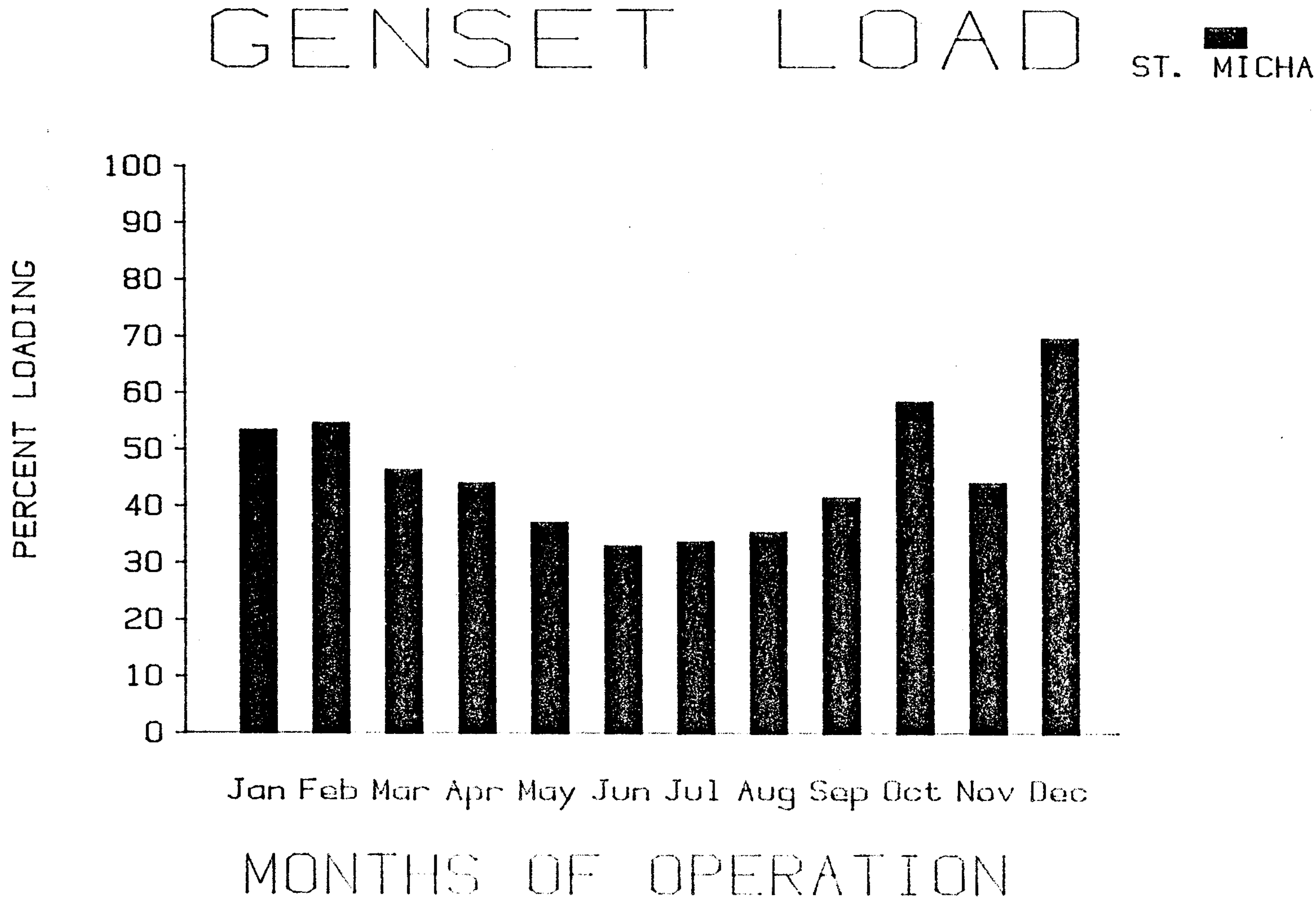
MONTHS OF OPERATION



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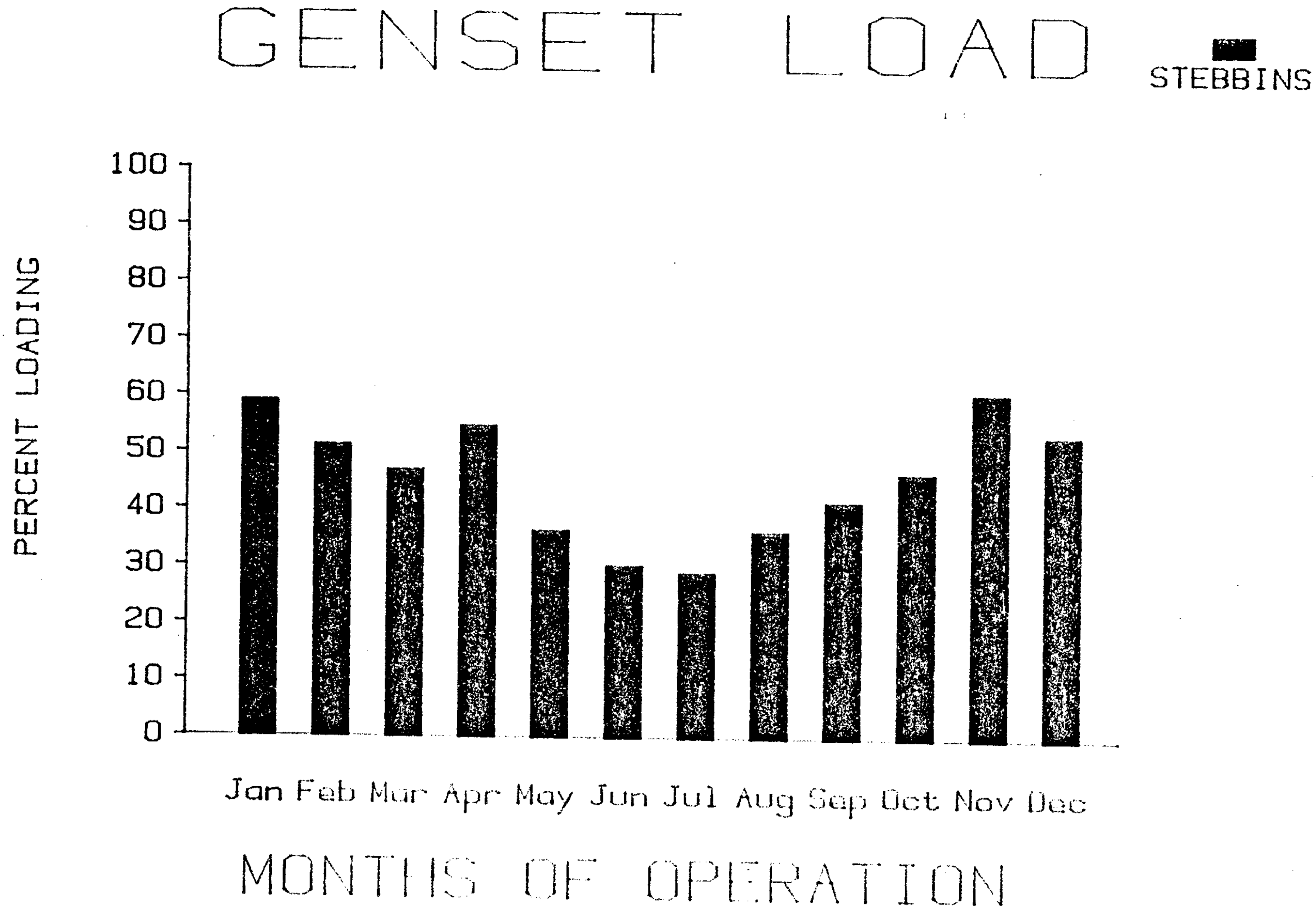
MONTHS OF OPERATION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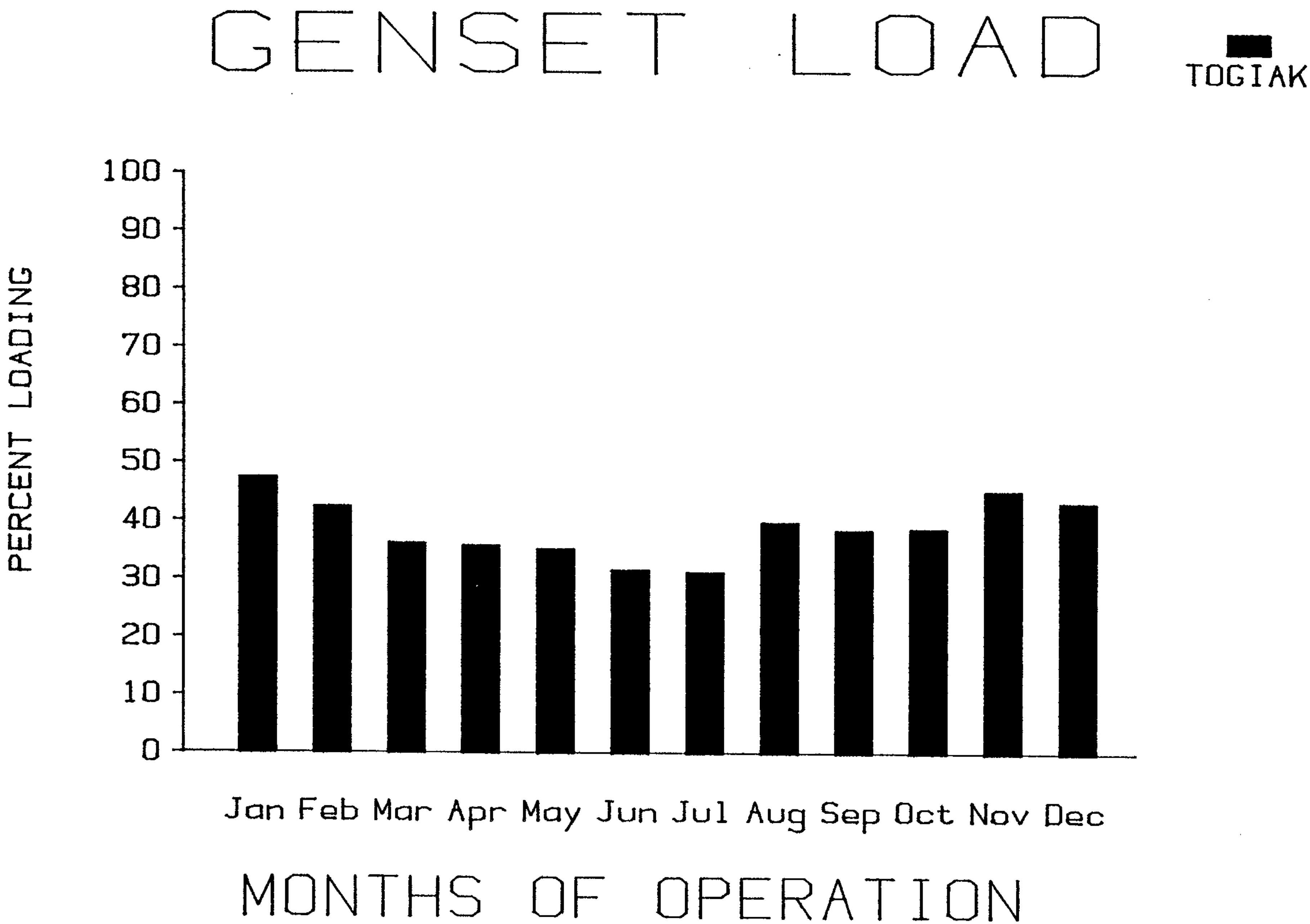
MONTHS OF OPERATION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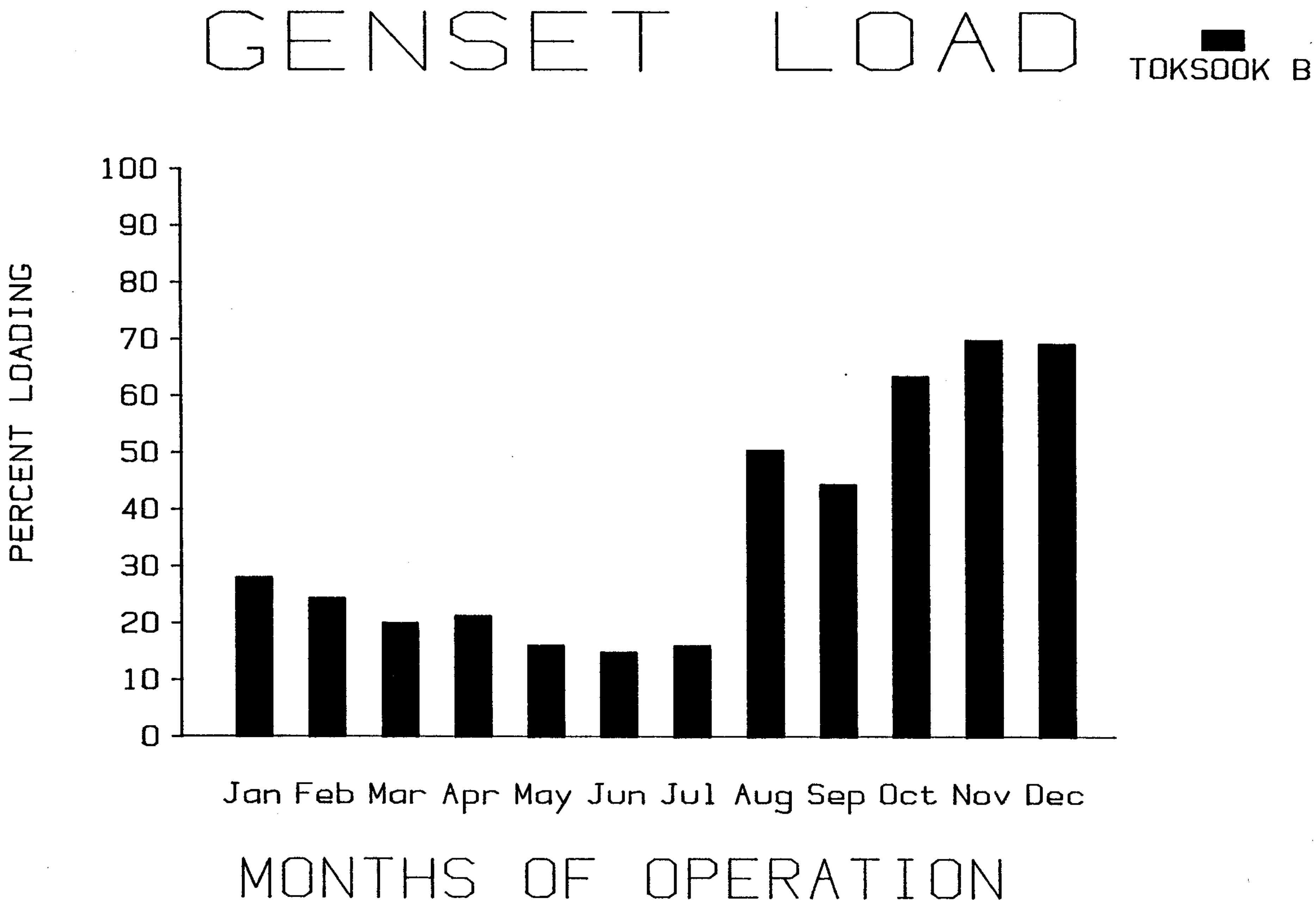
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTHS OF OPERATION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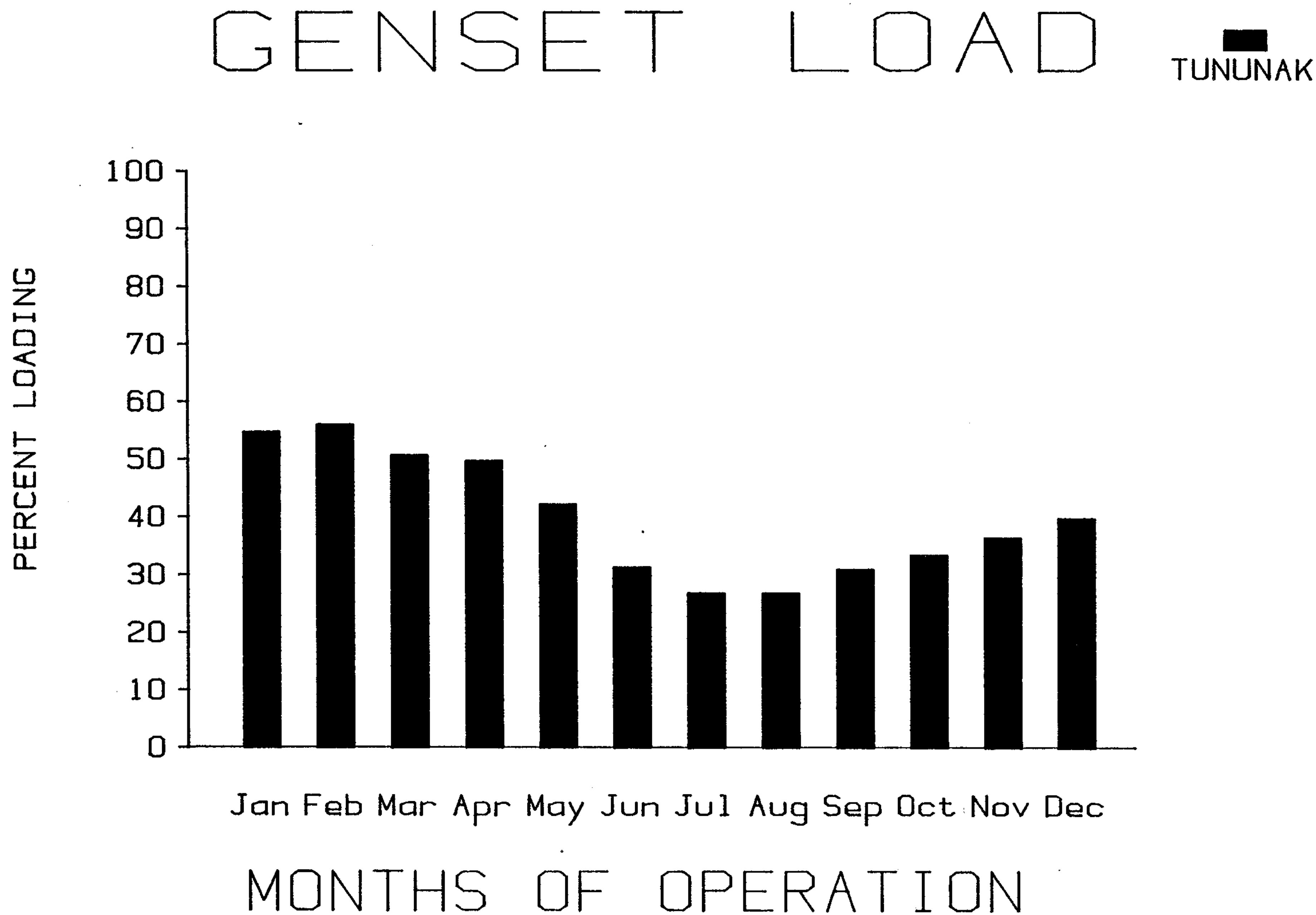
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTHS OF OPERATION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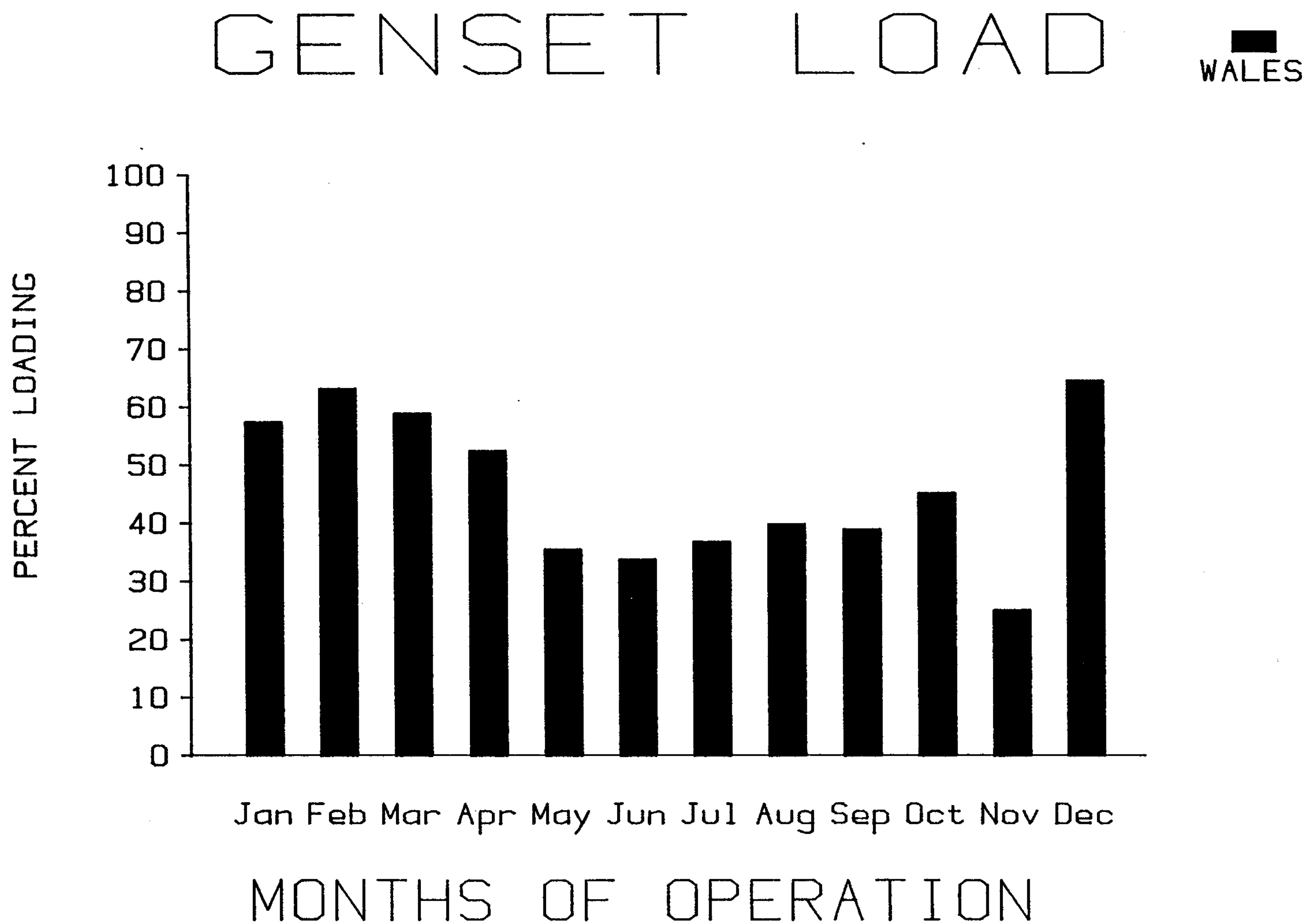
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTHS OF OPERATION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Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTHS OF OPERATION