Designing with G-E

VAC-U-SEL*

Component Rectifiers

GENERAL ELECTRIC

SEMICONDUCTOR PRODUCTS DEPARTMENT

a step-by-step method for selecting specific rectifiers

SECTION I—BASIC INFORMATION

INTRODUCTION

The phenomenon of asymmetric conduction was discovered over a century ago. It was not until the early 1920's, however, that the extended-surface semiconductor type rectifier was developed and manufactured commercially

At this time, the General Electric Company put on the market the copper-oxide-type rectifier, thus becoming one of the first manufacturers of semiconductor rectifiers in this country In the middle 1930's research was begun by this company on selenium rectifiers in commercial quantities.

Thus, it can be seen that for over a quarter of a century the General Electric Company has had experience in the development, design, and manufacture of semiconductor rectifiers. In recent years the tremendous increase in the number of applications for such rectifiers has stimulated further development and has brought out new techniques and improved rectifier characteristics.

At the same time, newer devices such as germanium and silicon rectifiers have been successfully developed by many rectifier manufacturers. These devices are superior to selenium rectifiers on many applications and will continue to gain increasing acceptance on more applications as technological advances are made and costs are improved.

However, there are many reasons why selenium rectifiers will not become obsolete. Certain features, such as large thermal mass, make them desirable on applications exhibiting high momentary peak currents. Their self-healing characteristic is also vital on essential service types of usage. Obviously, there are many considerations in applying the proper semiconductor It is the purpose of this booklet to clearly define the attributes and limitations of selenium rectifiers so the designer may be guided on where, how, and why to apply them.

This bulletin does not purport to cover all details or variations in these components nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company

1. MANUFACTURING PROCESSES

The manufacturing processes used by the manufacturers of selenium rectifiers vary considerably and the resultant products have a wide variation in characteristics, i.e., life, rating, forward voltage drop, reverse current, etc. It is necessary, therefore, that the reader recognize that there is a difference between the many types of selenium rectifiers on the market and evaluate each on its own merits. A characteristic of one device is not necessarily common to all.

The General Electric Company produces a selenium rectifier under the Trade Mark of Vac-u-Sel Rectifier which has an overall level of quality unmatched by that of any other manufacturer The Vac-u-Sel Rectifier is a product of a unique spherical vacuum evaporation process which the G-E Company pioneered in this country

Very briefly, the Vac-u-Sel Rectifier is made by evaporating selenium on a specially prepared back plate of aluminum in a controlled vacuum atmosphere within a large sphere. The final layer put on the cell is the counter electrode. See Figure 1 for a pictorial representation of the relative position of the various layers.

At this stage, the reverse voltage capability of the cell is rather low Therefore, a voltage is applied to the rectifier in the reverse direction for a definite length of time under controlled conditions. During this time a rectifying junction is formed between the selenium and the counter-electrode, thus producing the basic rectifier cell.

The vacuum evaporation process makes it possible to closely control the thickness of the selenium layers to satisfy varying requirements. This method also effectively acts to further purify the already highly pure selenium. When selenium is applied by the evaporation method, the preferred crystal orientation for rectification is obtained. Deposition in a spherical chamber contributes heavily toward greater uniformity on all cells in a batch. Uniformity of batches is held to close tolerances because of the precise control afforded by the spherical evaporation process.

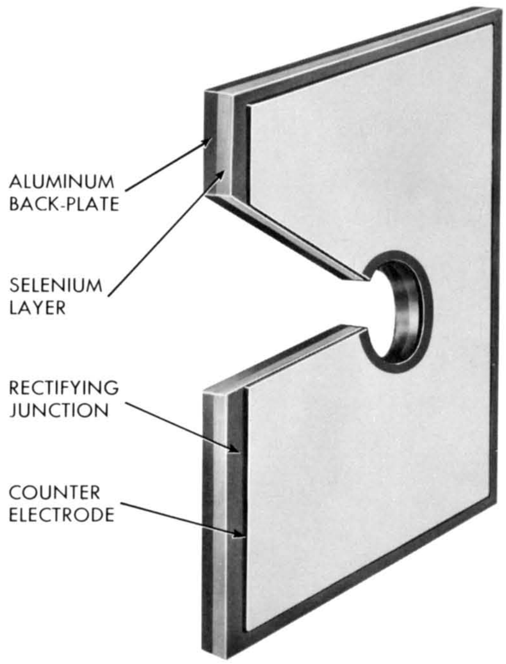


Figure 1. *Pictorial Representation of a Selenium Cell*

2. FUNDAMENTAL CHARACTERISTICS

Forward Voltage Drop

The selenium rectifier, being essentially a resistance device, produces a voltage drop when current flows through it in the forward direction. The magnitude of this voltage drop is, of course, dependent upon the resistance of the cell and the current density at which the cell is being operated. Figure 2 shows a typical dynamic forward characteristic.

Reverse Current

A selenium rectifier is not a perfect electrical valve but allows some small amount of current to flow in the reverse direction. Therefore, when a potential is applied with a polarity that will cause current to try to flow in the reverse direction through the rectifier, there is some flow of reverse current. The greater the reverse voltage on the cell, the greater will be this reverse current. Figure 2 also shows a typical dynamic reverse characteristic.

Unforming

Selenium rectifiers will unform when inactive and their reverse resistances will decrease correspondingly The amount of unforming varies with the

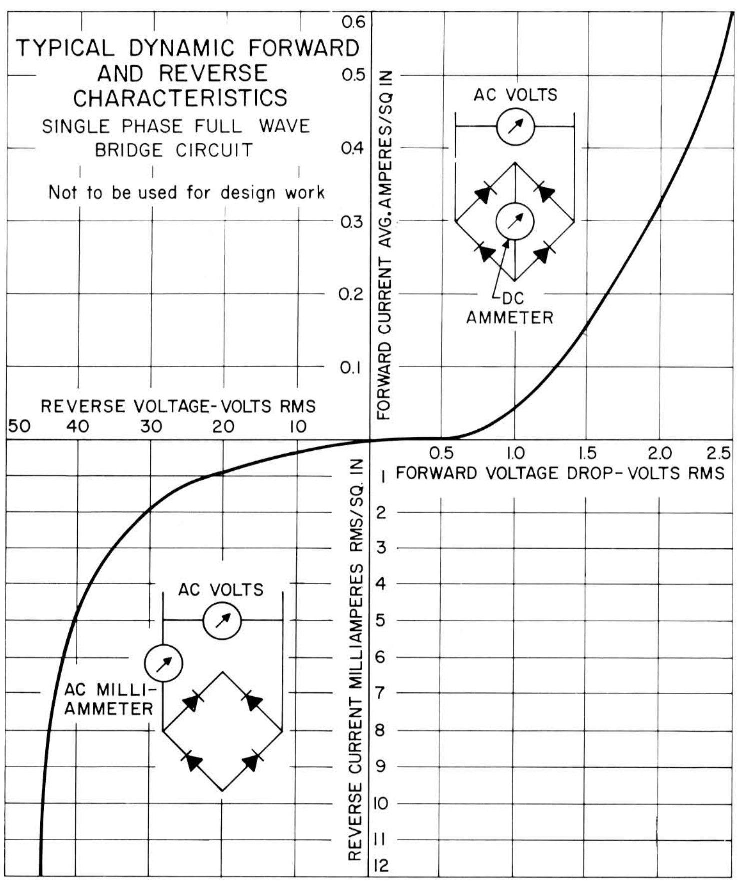


Figure 2.

Unforming (Cont.)

ambient temperature and the length of time that the cell is out of the circuit. Upon resumption of power, the reverse current will be high, but will return to its normal value in a few cycles. If a rectifier is suspected to be badly unformed, it would be advisable to apply voltage gradually in steps until the rated voltage is reached. The unforming characteristic will restrict the use of selenium rectifiers whenever instantaneous blocking is required following long periods of inactivity

Non-Linear Characteristic

The forward and reverse dynamic characteristic shown in Figure 2 shows that a selenium rectifier is a resistance device with a non-linear characteristic. The forward resistance or forward voltage drop, exhibits a negative temperature coefficient within a temperature range of —60 to +140°C (see Figure 3) The reverse resistance will have either a positive or negative temperature coefficient depending upon the temperature at which it is being operated. (see Figure 4)

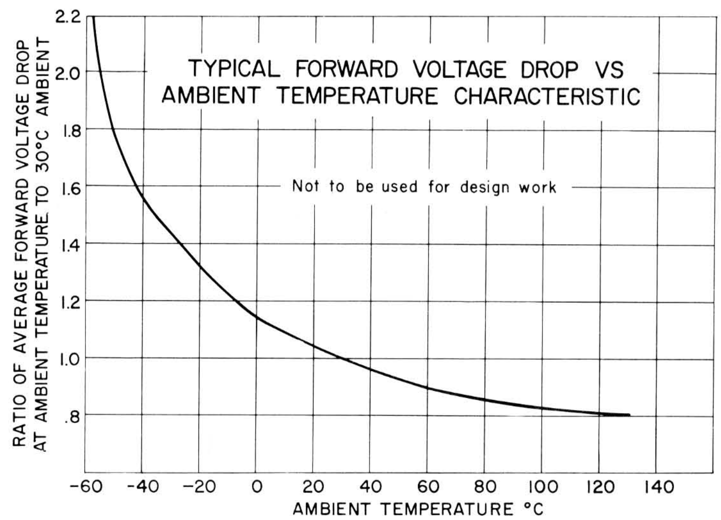


Figure 3.

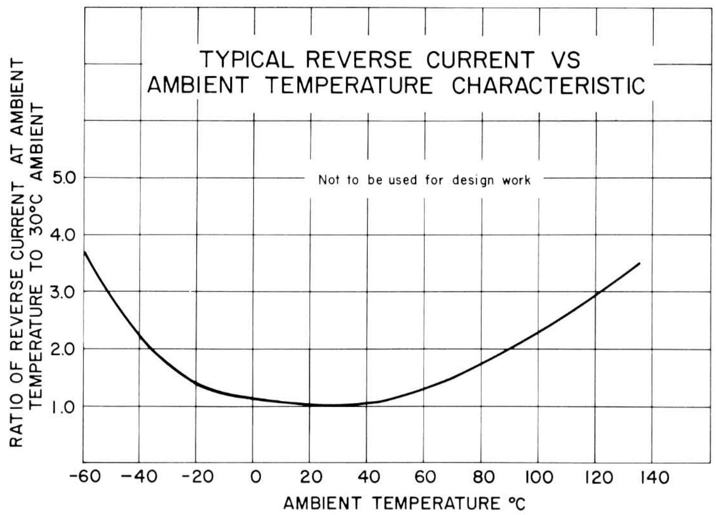


Figure 4.

Aging

Aging is defined as any persisting change (except failure) which takes place for any reason in either the forward or reverse resistance characteristics of a rectifier The most significant change in a selenium rectifier is the gradual increase of the forward resistance. The reverse resistance will also change with time, some makes increase while others decrease but most tend to stabilize and remain within tolerable limits.

The effect of aging is a gradual dropping off of d-c output voltage for a constant a-c input voltage. Concurrently with this voltage reduction, there is a loss of efficiency and an increase in temperature rise for a constant load current. The severity and rapidity of aging is dependent upon the method of manufacture of the rectifier, its initial electrical characteristics and the current, voltage and temperature at which it is operated. The more uniform the thickness and crystalline structure of the selenium layer, the slower the aging. These characteristics are closely controlled in the Vac-u-Sel process for longest life.

The effect in a given circuit of the increase in forward resistance is dependent upon the design of the circuit. For example, if the rectifier resistance is initially 10 percent of the total circuit resistance, the increase of 50 per cent in forward resistance would reduce the rectifier output approximately 5 per cent with constant applied voltage. On the other hand, if the rectifier resistance initially were 50 per cent of the total circuit resistance, the same increase in forward resistance would result in approximately a 20 per cent decrease in output.

Cause of Aging

Aging is a function of operating temperature of the cell and the current density imposed upon the cell. The two are almost inseparable because the criterion for the rate of aging is the actual temperature of the rectifying junction, which is the boundary between the selenium layer and the counter electrode. Operating the cell at high ambient temperatures with low current density will produce similar aging characteristics as artificially cooling the device at very high densities, as long as the junction is running at the same temperature.

Life Expectancy

There is a time at which the loss of output due to aging exceeds a predetermined amount. At this point, the rectifier is considered to have reached its end of life. The actual values of output and input voltage and current rating, at this time, should be the published ratings as they appear in Tables 1 and 2, Section III. Operation beyond the aged condition simply means that rated output may no longer be maintained. Under normal conditions, the life expectancy of G-E Vac-u-Sel Rectifiers will be in excess of 80,000 hours. Most Vac-u-Sel Rectifiers will exceed this length of time because all ratings are based on minimum limit cells.

During the early days of the art, it was thought that the selenium cell with the lowest forward resistance would be the cell with the longest life span. This is not necessarily true. Tests of cells made by different manufacturing processes having identical initial low forward resistance have exhibited widely varying rates of aging. It has also been demonstrated by life tests that certain cells of higher forward resistance can have a lower aging rate and a resulting longer life expectancy The Vac-u-Sel Rectifier process optimizes forward drop and long life.

Operating the selenium rectifier at various combinations of current density, ambient temperature, voltage levels and methods of cooling above and below normal ratings will produce varying life spans. In other words, if a finite life expectancy is desired, it is possible to select a set of operating conditions that will produce the anticipated performance. Section III in this manual will show the designer the techniques to follow in this approach to select a rectifying cell that will provide exactly what is required of this application

1. at the lowest cost
2. in the smallest physical package

Self Capacitance

A selenium rectifying cell is similar to a capacitor in construction. The counter electrode is one plate and the selenium layer is the other—the rectifying junction being the dielectric. Measurements indicate that the capacity changes with frequency and applied voltage. By superimposing a high frequency a-c ripple on a d-c bias voltage, these measurements can be made. It was found that at 4 volts d-c applied with a 1 kc per second a-c ripple, a typical self-capacitance value for Vac-u-Sel Rectifiers was approximately 0.08 microfarads per square inch. A decrease in applied d-c voltage indicated an increase in capacitance and vice versa. At 0 volts d-c, the capacitance was measured at approximately 0.24 microfarads per square inch.

There is no appreciable drop in output, and therefore no increase in forward impedance, when applied voltages at frequencies up to 6 kc and better are used but there is a decided change in the reverse characteristic. Reverse current increases appreciably with an increase in frequency See Figure 5. Therefore, a selenium rectifier must be operated at a frequency that will keep the reverse current within a reasonable value.

The value of self-capacitance of other types of selenium rectifiers will vary in magnitude according to the method used in the manufacture of the cell.

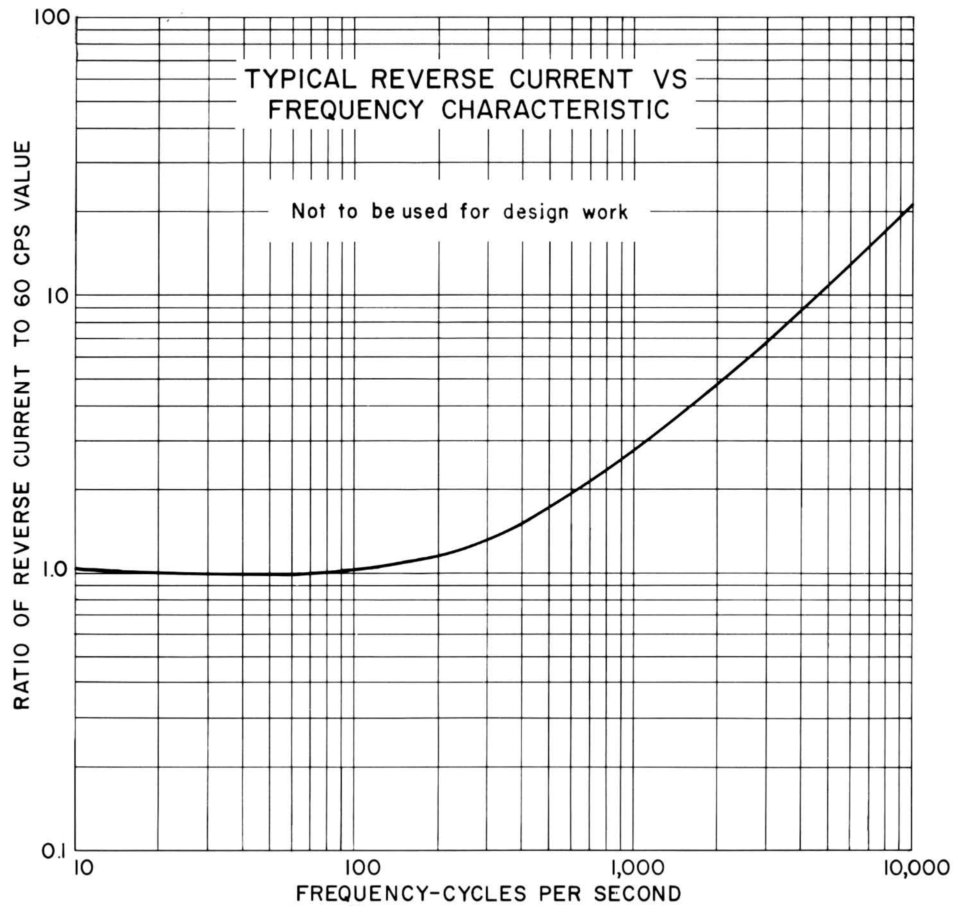


Figure 5.

Relationship of Voltage and Current Input-Output

Most design engineers are familiar with the theoretical relationship of input and output in rectifier circuits. These values are based on ideal conditions such as pure sinusoidal wave shapes, zero resistance in the conducting direction and infinite resistance in the blocking direction of a rectifier Since these conditions do not exist in actual practice, it is necessary to modify the theoretical values and assign empirical values based on laboratory tests. These values will differ slightly with cells of different manufacture. A listing for each type of circuit and load for Vac-u-Sel Rectifiers may be found in Section III, Table I (Pages 16-17)

These empirical relationships must be further compensated to include a variable voltage drop which is a function of the current density being carried by the cell. Figures 5, 6, 7, and 8 in Section III show the average voltage drop for different current densities and for all three types of cells (26, 36, and 45 V rms)

Efficiency

Rectified a-c has both a-c and d-c components present. Therefore, the power output can be measured either with a-c instruments or d-c instruments depending upon whether both the a-c and d-c components produce useful work or if only the d-c is used. Normally, we are only interested in the d-c components in the output of the rectifier This should be measured with a d-c ammeter and a d-c voltmeter When the output is so measured and the a-c input measured with an a-c wattmeter, conversion efficiency

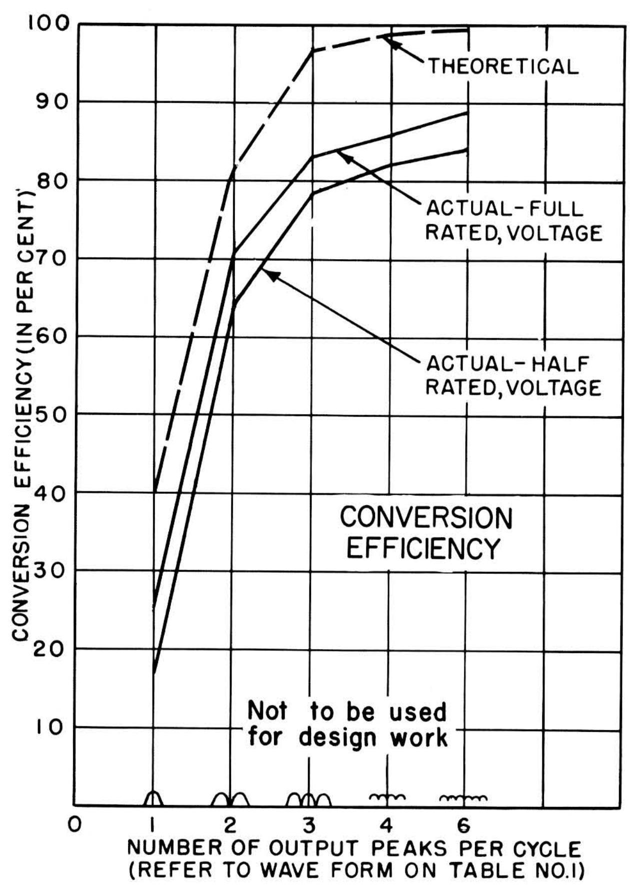


Figure 6.

Efficiency (Cont.)

can be calculated. The formula for the conversion efficiency is

$$\frac{Idc \times Edc \times 100}{\text{Power In}}$$

The difference between conversion efficiency and the efficiency obtained by dividing the true power output, as measured by a-c instruments, by the a-c power in, is that the latter is independent of the type of circuit used. A perfect rectifier efficiency would be 100 per cent. Conversion efficiency, on the other hand, varies with the rectifier circuit and only reaches 100 per cent, theoretically, when the number of phases in the rectifier circuit (i.e. number of peaks in the output waves) is infinite. The dotted line in Figure 6 shows the theoretical values for the various circuits in terms of output peaks per cycle. The solid lines give the actual values of efficiency for the circuit when operated at rated voltage and half-rated voltage. These values are average, new efficiencies for circuits using 26 volt rms cells. A drop of 8 to 10 per cent from these values can be expected after the forward resistance of the rectifier cells has increased 100 per cent.

Transformer Design

There are several special considerations necessary in transformer design as related to rectifier circuits which are not important in standard a-c circuits.

In some circuits the primary and secondary kva ratings of the power transformer are different due to the type of connections required. Their theoretical values are shown in Table 1. In actual design work it is necessary to figure rectifier efficiency, power factor, and transformer efficiency to obtain primary and secondary rating. Therefore, to obtain a transformer secondary kva rating the rectifier maximum d-c output power in watts should be divided by the appropriate rectifier efficiency and power factor to obtain the secondary volt-amperes required. The primary rating for the transformer and the secondary current can be calculated using the values given in Table 1.

Furthermore, consideration must be given in transformer design to the aging of the rectifier If constant d-c output is required over the life of the rectifier, it is necessary to provide means to change the input voltage to maintain this output. Normally, this is done with transformer taps which cover a range in secondary voltage from that which is required when the rectifiers are new to a maximum voltage equal to the maximum rating of the stacks. The spacing and number of the taps is dependent upon the application. Normally, these taps are on the secondary winding of the transformer If the rectifier is used in an application where there is very little chance of aging taking place or if there is no need to control the output voltage of the rectifier, aging taps need not be used.

It is standard practice to provide line-voltage taps on the primary if the equipment is to be used in applications where variations from the nominal line voltage are anticipated.

When designing a transformer for use with a rectifier it is important to consider the application for which the rectifier is being used. Ratings will vary under different load conditions.

Selenium Rectifier Ratings

As with all electrical equipment the selenium rectifier is rated in accordance with its voltage, current and thermal characteristics. Each one of these characteristics are closely inter-related and all three have a direct effect on the length of operating life of the rectifier Therefore, it is important that the length of operating life desired of the rectifier be considered when ratings are assigned. Handbook ratings are chosen to give the optimum life expectancy

Since the characteristics of selenium rectifiers vary considerably with methods of manufacture, it is impossible to arrive at ratings which are applicable to all selenium rectifiers independent of the process used in the manufacture. Therefore, the following will deal exclusively with General Electric Vac-u-Sel Rectifiers produced by the evaporation process. However, where practicable, the methods of rating and the ratings themselves correspond to those approved by the NEMA Committee on Selenium rectifiers.

SECTION II—PRODUCT DESCRIPTION

INTRODUCTION

Vac-u-Sel Rectifiers are almost impossible to list by model number because of the great number of combinations possible. There are close to a million model numbers that could comprise a listing of standard rectifiers, all of which are available. In addition there are an infinite number of specials or variations which could be obtained.

Generally, each rectifier is custom-made to fit a specific application. The size, rating, combination, and number of cells to be used and the method of stacking the cells, varies with each requirement and rarely are two requirements satisfied by the same rectifier Although each rectifier is custom-made and varies according to the customer's requirements, the rectifying cells, which are the building blocks of the rectifier, are standard. Therefore, we define and apply rectifiers by their basic elements, the individual cells.

The techniques used in applying Vac-u-Sel Rectifiers are fully explained in Section III.

1. THE VAC-U-SEL RECTIFIER LINE

There are several different sized cells in the line of Vac-u-Sel Rectifiers, each available in two or more voltage ratings. All cell sizes up to two inches square are available in 26, 36, and 45 volts (rms) per cell. The larger sized cells are available in 26 and 36 volts (rms) per cell. 18 volt cells are available on special order to meet certain customer requirements in all sizes.

All three standard cell types are produced by General Electric Company's unique spherical evaporation process. This process produces very high quality cells with extremely long life expectancy, capable of operating at a high ambient temperature and at high current density

The 26 volt cell can meet ambient temperature operating requirements up to 130°C at full voltage. Current need not be derated where shorter life is acceptable. Life expectancy at 130°C is 1500 hours. At 35°C ambient temperature, the life expectancy is at least 80,000 hours.

The 45 volt cell has a 63 volt peak reverse voltage. Unlike most 45 volt rectifiers, this is a true, long life, industrial cell. Frequently this rectifier may be substituted for one employing 26 volt cells. Since fewer cells are required, savings up to 30 per cent in cost, and up to 35 per cent in size of rectifier are possible. Normal life expectancy at 35°C of this 45 volt cell is 60,000 hours. The cells can be used at ambient temperatures up to 110°C with a life of 3,000 hours. The 36 volt cell exhibits the same characteristics as the 26 and 45 volt cells and has a life expectancy comparable to that of the 45 volt cell.

All Vac-u-Sel Rectifiers operate with low forward voltage drop and low reverse current, and their margin of superiority in these characteristics increases in service. All Vac-u-Sel Rectifiers undergo extensive testing and grading, and matched cells are used in assembling rectifiers. A variety of finishes and mounting arrangements are available to meet virtually any requirements.

2. FINISHES

Vac-u-Sel Rectifier stacks can be supplied with three basic types of finishes.

Standard Commercial Finish — is normally used for industrial applications as found in the environmental conditions of the continental U.S.A.

Heavy Duty Commercial Finish is usually recommended for use in high humidity and for Vac-u-Sel Rectifiers which are exposed to mild acid and alkaline atmospheres.

Military Finish — for use in military applications where protection is required for 100 hour salt spray, humidity and fungus. In cases where longer periods of time, that is where more than 100 hours of salt spray or 30 days at 100 per cent humidity are encountered, oil-immersed or embedded rectifiers are usually recommended. However, on special applications it is possible to meet a 200 hour salt spray requirement with open type construction. All such requirements must be negotiated individually.

Embedded Rectifiers — The intermediate size rectifiers are available embedded in a special potting compound. This produces a lightweight rectifier useful on military applications, especially at high altitudes, when oil-immersed rectifiers can not be easily used because of oil leakage in the rare atmosphere.

Other Special Miniature Models — The 5/32 inch miniature may be housed in a ceramic tube with military finish. The 9/32 inch and 15/32 inch cells are available in hermetically sealed, metal clad or glass tubular housings.

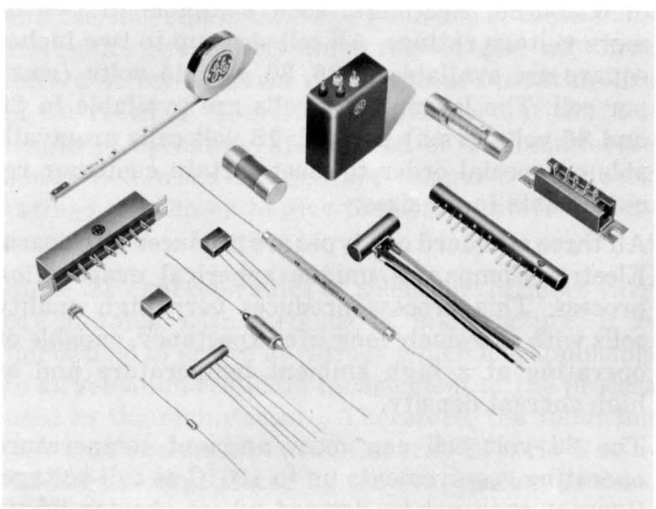
3. CONSTRUCTION OF RECTIFIERS

Selenium cells are assembled into a variety of mountings with terminals for convenient installation.

Miniatures

The smaller sizes of cells up to 15/32 inch diameter, known as miniatures, have no center mounting hole and are mounted close together without spacer washers between cells, assuring compact assemblies. They are available in many types of tubular housings. Phenolic, Textolite, metal, ceramic, and glass tubular housings are used as well as special clip assemblies and molded packages. These miniatures have several important advantages

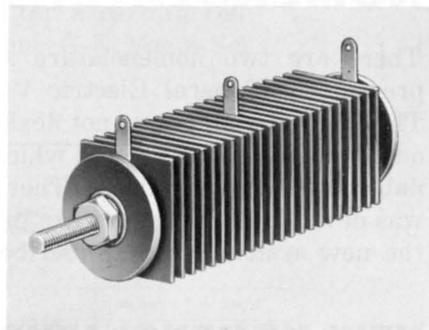
- Low cost
- Small, light weight
- Easy to connect in circuit
- Well protected against abuse from handling



Typical Miniature Vac-u-Sel Rectifiers

Stud Mounted

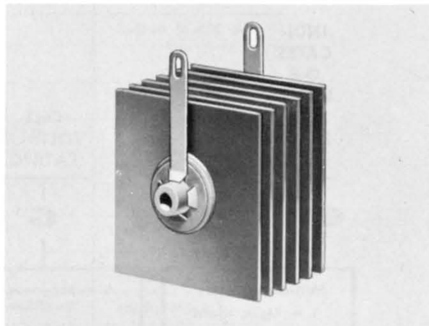
Cells 1 inch and larger have a center hole for mounting on a stud The selenium cells are slipped over a metal stud that is insulated from them by a phenolic tube. A contact washer is then slipped over the mounting stud and placed against the counter-electrode surface, to provide a current-collecting surface. This washer touches the cell only at the periphery of the washer Each cell is separated by either metal spacer washers or insulated spacer washers, depending upon whether or not direct connection between the cells is required by the particular circuit in which it is used. A-c and d-c terminals are assembled over the mounting stud as required. If necessary, jumper wires between terminals are used to make electrical connections with other parts of the rectifier By combinations of these components, any rectifier circuit or combination of circuits can be incorporated on a mounting stud. When desired, mounting brackets and special screw-terminal connections can be supplied.



Standard Stud-mounted Vac-u-Sel Rectifier

Eyelet and Tube Mounted

Eyelet and tube mounted rectifiers differ from the standard in that they have no through stud and nuts. This results in a cost saving but does not provide the same mechanical properties. The tube construction is generally used for applications where price is important. It is available for the 1, $1\frac{1}{2}$ and 2 inch square cells and can accommodate up to 18 cells. Another inexpensive assembly is the metal eyelet design. This is rather special and available only in the 1 and $1\frac{1}{2}$ inch square sizes and a maximum of 8 cells in a rectifier



Tube Mounted Vac-u-Sel Rectifier

4. SPECIAL CONSTRUCTIONS

Oil Immersed

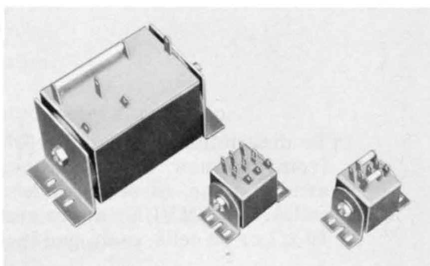
Oil-immersed rectifiers provide complete protection from severe atmospheric conditions such as strong acid fumes, moisture, fungus, and other substances that may combine chemically to damage the selenium cells. The rectifier cells within the can are usually assembled on a stud. The largest cell that can be conveniently hermetically sealed in the standard container is the $4\frac{3}{8}''$ round.

Oil-immersed Vac-u-Sel Rectifiers

Embedded

1 inch, $1\frac{1}{2}$ inch, and 2 inch square rectifiers are the only sizes available in the embedded design. Up to 40 cells can be assembled in one package making it possible to obtain a wide variety of cell combinations. No derating of current or voltage is necessary even though the cells are completely enclosed.

This is a key feature of Vac-u-Sel Rectifiers.



Embedded Vac-u-Sel Rectifiers

5. NOMENCLATURE

There are two nomenclature systems in use at present for General Electric Vac-u-Sel Rectifiers. The original system was not flexible enough to thoroughly cover all the factors which should be identifiable from a model number Therefore a new system was devised. Both systems are in use, however only the new system will be described in this Section.

These definitions are given so that information about a particular rectifier can be readily obtained from its model number When using this information to assign model numbers, be certain to make note of it on the first correspondence with the General Electric Company

NEW NOMENCLATURE – KEY TO MODEL NUMBER

Example: Model No. 6RS21GB10AAC1

INDICATES G-E SELENIUM RECTIFIER	CELL TYPE AND SIZE	CELL VOLTAGE RATING	CIRCUIT AND NO. OF ARMS	NO. OF SERIES CELLS†	CONSTRUCTION DETAILS	STACK FINISH AND CELL TEMPERATURE RATING	NO. OF PARALLEL CELLS†
6RS	**21**	**G**	**B**	**10**	**AA**	**C**	**1**

CELL TYPE AND SIZE

Miniature Types
- 1 = 3/32 in. round
- 5 = 9/32 in. round
- 6 = 5/32 in. round
- 20 = 15/32 in. round

Intermediate Types
- 21 = 1 in. square
- 22 = 1 ½ in. square
- 25 = 2 in. square

Large Types
- 14 = 3 ⅜ in. round
- 15 = 4 ⅜ in. round
- 31 = 4 ¼ in. x 6 in.
- 32 = 5 in. x 6 in.

CELL VOLTAGE RATING
- A = Magnetic amplifier
- C = 18 Volts (rms)
- G = 26 Volts (rms)
- L = 36 Volts (rms)
- P = 45 Volts (rms)

CIRCUIT AND NO. OF ARMS

Circuit
- H = 1ϕ Half Wave
- D = 1ϕ Doubler
- C = 1ϕ Full Wave Center Tap
- B = 1ϕ Full Wave Bridge
- Y = 3ϕ Half Wave
- F = 3ϕ Full Wave Bridge
- S = 3ϕ Full Wave Center Tap
- M = 1ϕ Open Type Bridge
- X = Special

No. of Arms
- B = 4
- C = 2
- D = 2
- F = 6
- H = 1
- M = 4
- Y = 3

CONSTRUCTION DETAILS
- AA = Standard Stud
- AB = AA + Brackets
- AC = AA + Screw Terminal
- AD = AA + Brackets and Screw Terminals
- AR = Eyelet (1 inch & 1 ½ inch)
- AT = Phenolic Tube (1, 1 ½, & 2 inch)
- BA to CZ—Specials—refer to G-E Co.
- KA = Cup Contact Washer
- KB = KA + Brackets
- RA = Clip assembly
- TA = Tube with inside holding rings (special)
- TB = Slotted tube with metal feet
- TC = Tube with insulated caps (special)
- TD = Ceramic Tube
- TE = Tube with hot caps no leads (special)
- TH = Tube with hot caps and leads (standard)
- TM = Metal Clad
- WA = Oil-immersed, No Bracket
- WB = WA + Brackets

STACK FINISH AND CELL TEMPERATURE RATING
- B = No finish High temperature
- *C = Standard finish High temperature
- D = Standard finish High temperature
- *E = Heavy duty High temperature
- F = Heavy duty High temperature
- *G = Military finish High temperature
- H = Military finish High temperature
- J = Potted High temperature

†To determine total number of cells in a rectifier from the new nomenclature, multiply (no. of arms) x (no. of series cells) x (no. of parallel cells) EXAMPLE: above rectifier will have 4 x 10 x 1 or 40 cells, each, one-inch square.

*Formerly low temperature cells now obsolete; listed for reference only

APPLICATION WORK SHEET (ECG-344-1)

Standard Stack Combinations Available

This tabulation is made to define the limitations of cell-voltage ratings, types of housing (or construction), types of finishes and number of cells allowable in a certain housing for each type of cell. If your particular application requires construction or electrical features which are not standard for a certain cell type, check for other possible combinations or refer to your G-E Vac-u-Sel Rectifier Sales Representative.

General Classification	Cell Type (Size)	Cell Voltage Rating Avail.	Types of Construction	†Max. No. of Cells Allowable For Std. Mounting	Finishes Available	Remarks
Miniature Sizes	5 (9/32" round)	G	*TH TE	200	B D F H	
			*TM	40		no extra fnsh. req'd
		L	TA (Slotted)	116	B J	
			*TA (Open-End)	250	B J	not for MIL use
		P	RA	6	D F	limited to 85C amb.
	6 (5/32" round)	G	*TH TE	250	B D F H	
		L	RA	6	D F	limited to 85C amb.
		P	TA (Slotted)	96	B	
	20 (15/32" round)	G	*TA (Open-End)	100	B J	
			*TH TE	230	B D F H	
		L	*TM	40		no extra fnsh. req'd
			TB	112	B J	
		P	RA	6	D F	limited to 85C amb.
Intermediate Sizes	21 (1 x 1") 22 (1.5 x 1.5")	G	AR	8	D F H	not for MIL use
			AT	18	D F H	not for MIL use
		L	AT	40	J	
		P	AA AB AC AD	40	B D F H	
	25 (2 x 2")	G	AT	16	D F H	not for MIL use
		L	AT	40	J	
		P	AA AB AC AD	40	B D F H	
Large Sizes	14 (3 3/8" round)	G L	AA AB AC AD KA KB	36	B D F H	KA & KB design for MIL use must be approved by factory engineers.
	15 (4 3/8" round)			28		
	31 (4 1/4" x 6"		AC AD KA KB	24		
	32 (5 x 6)"			24		

Finishes (High Temp. Cells)

B. No Finish.
D. Std. Com. Finish.
F Hvy Dty Com. Finish.
H. Military Finish.
J Potted or Embedded.

Voltage Ratings Per Cell

G = 26 Vrms
L 36 Vrms
P 45 Vrms

†No. of cells could be increased on special applications.

*Available only as two terminal stacks.

Construction Details

AA — Standard Stud.
AB = AA + Brackets.
AC AA + Screw terminals.
AD — AC + Brackets.
AR = Mounted on a rivet.
AT — Mounted on a tube.
KA — Cup contact washer design.
KB KA + Brackets.
RA Assembled in an insulated metal spring clip.
TA — Assembled in a tube, open ends or slotted.
TB Assembled in a tube, square, slotted.
TE Assembled in a tube, end caps, no leads.
TH Assembled in a tube, end caps, with leads.
TM — Assembled in a tube, metal clad.

General Electric Vac-u-Sel* Rectifiers

APPLICATION WORK SHEET (ECG-344-1)

CUSTOMERS NAME AND LOCATION ____________________

Proposition No. ______________ Date ______________ G-E Office ______________

DATA

Function of Rectifier ______________ Type of Load ______________

Cust. Specs or Dwgs ______________ Amb Temp ________ °C Life Expec ________ hrs

Load Current ________ Continuous ________ Convection ________ or Forced Cooled ________ LFPM

If Intermittent load ________ time on ________ secs Time off ________ secs

Voltage Requirements ______________ AC or DC Type of Circuit ______________

PROCEDURE

Fill in all spaces in DATA. Use Application Manual in completing the following:

1 CIRCUIT INFORMATION

Circuit Symbol ______________ Number of Arms in circuit ______________

Circuit Constant (C) ______________ Conversion Factor (K) ______________

2. VOLTAGE-RATING SYMBOL ______________ **CELL-VOLTAGE RATING** ______________ **RMS**

3. NUMBER OF SERIES CELLS REQUIRED PER ARM (N_s)

$$N_s \quad \frac{\text{Voltage Required}}{\text{Voltage Rating per Cell}} \quad \underline{\qquad\qquad} = \underline{\qquad\qquad}$$

(When N_s is not a whole number, use next higher whole number.)

4. TOTAL CELLS REQUIRED

(Number of arms) (Number of series cells) = (______) (______) = ______

5. EQUIVALENT CURRENT RATING (ECR)

$$ECR = \frac{\text{Load Current}}{\text{Current Index}} \quad \frac{(\qquad)}{(\qquad)} \quad \underline{\qquad\qquad}$$

6. CELL TYPE NUMBER ______________

7 CURRENT DENSITY RATIO (CDR)

$$CDR \quad \frac{\text{Load Current}}{(N_p)\ \text{NEMA rating of cell}} \quad \frac{(\qquad)}{(\quad)(\quad)} \quad \underline{\qquad\qquad}$$

(V_d) Cell voltage drop ______________

8A. INPUT OR OUTPUT REQUIREMENTS (NEW)

(a) AC Volts Input — (K) [(V DC + (C) (N_s) (V_d)] = (   ) [________ + ________] = ________

or

(b) DC Volts Output $\frac{V\ AC}{K}$ (C) (N_s) (V_d) $\frac{(\qquad)}{(\qquad)}$ — (   ) — ________

8B. INPUT OR OUTPUT REQUIREMENTS (AGED)

(a) AC Volts Input — (K) [(V DC) + 2 (C) (N_s) (V_d)] = (   ) [________ + ________] — ________

or

(b) DC Volts Output $\frac{V\ AC}{K}$ 2 (C) (N_s) (V_d) = $\frac{(\qquad)}{(\qquad)}$ — (   ) ________

9. MODEL NUMBER

	6RS						
	cell type	voltage symbol	circuit symbol	series cells	construction details	finish	parallel cells
From Step No.)	(6)	(2)	(1)	(3)	(See Reverse Side)	(See Reverse Side)	(6)

Be sure to check construction-detail data on reverse side of this sheet before completing model number. Data there will tell you what construction details are available with each cell type.

10. QUANTITY REQUIRED

Order number of Rectifier Stacks required per supply

Refer to your G-E Vac-u-Sel Rectifier Sales Representative for prices or additional information.

Signed ______________ Location ______________

SECTION III—HOW TO APPLY G-E VAC-U-SEL RECTIFIERS

INTRODUCTION

The "on-the-spot" selection procedure is designed to assist those interested in designing a rectifier "on-the-spot." The chief benefit is the saving of time that would otherwise be spent waiting for factory assistance. Basically, it makes it possible to design a rectifier to a specific application in a do-it-yourself fashion. In addition, it helps bring to light many factors which sometimes go unnoticed and are very important criteria in the selection of the proper rectifier

It must be recognized that no practical method could be devised to cover every situation. However, this section will solve all general types of applications with comparative ease and accuracy If the application is complicated by unusual requirements such as non-sinusoidal wave shapes, pulse circuits, etc. or this section is inadequate in any respect, it should be referred to the nearest General Electric Vac-u-Sel Rectifier Sales Office.

The calculations for the correct rectifier should be followed step by step as shown on the Application Work Sheet (ECG-344-1) using the tables and figures referred to in this section. Copies of (ECG-344-1) are available in pad form from your Vac-u-Sel Rectifier Sales Representative.

A sample work sheet is shown on page 14. Reference to this will be of value while following calculations outlined on the following pages.

CALCULATION GUIDE FOR APPLICATION WORK SHEET (ECG-344-1)

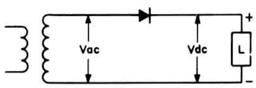
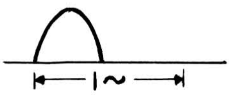
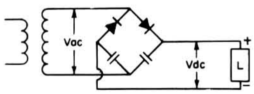
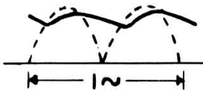
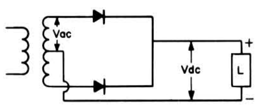
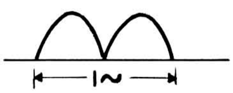
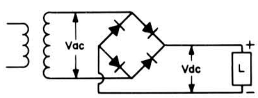
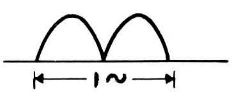
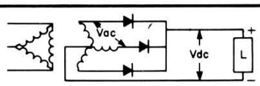
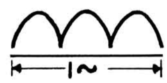
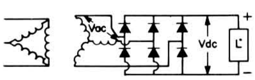
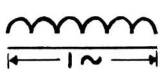
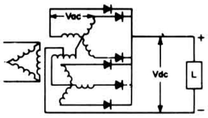
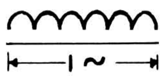
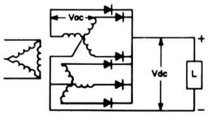
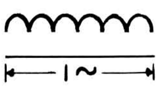
(See Pages 13 and 14)

1. CIRCUIT INFORMATION

Circuit Symbol______Number Arms in Circuit______Circuit Constant (C)______Conversion Factor (K)______

Refer to Table 1 below to obtain circuit information.

TABLE 1—FUNDAMENTAI

Type of Circuit	Circuit Diagram	Circuit Symbol	No. of Arms	Cell Combination	Circuit Constant (C)	Output Voltage Waveform
SINGLE PHASE						
Half Wave		H	1	1 1 1-H	1	
Full Wave Doubler		D	2	2-1 1-D	2	
Full Wave Center Tap		C	2	2-1-1-C	2	
Full Wave Bridge		B	4	4-1 1-B	4	
THREE PHASE						
Half Wave		Y	3	3-1 1 Y	3	
Full Wave Bridge		F	6	6-1 1-F	6	
Full Wave Center Tap (I.P T.)		S	6	6-1 1-S	3	
Full Wave Center Tap		S	6	6-1 1-S	6	

$K = \frac{E_{rms}}{E_{dc}}$

I_{ac} RMS Current per cell.

I_d = Average Current per cell.

I_p = Peak Current per cell.

I_l = Direct Current in load.

N_p = Number of cells in parallel per circuit element.

*For capacitive loads calculate K from Fig. 1 (below)

†Dependent upon circuit parameters.

RECTIFIER CIRCUITS

% Ripple	Type of Load	Conversion Factor (K)	I_{a-c}	I_d	I_p	Ratio Primary to Secondary VA
121	Resistance Inductance Battery Capacitance	2.25 2.25 0.9 *	1.60 I_1/N_p 1.60 I_1/N_p 2.60 I_1/N_p 2.60 I_1/N_p	I_1/N_p	3.14 I_1/N_p 2.0 I_1/N_p † †	1:1.0
	Capacitance	*	— — —	I_1/N_p	†	1:1.0
48	Resistance Inductance Battery Capacitance	1 125 1 125 0.85 *	0.80 I_1/N_p 0.80 I_1/N_p 1.20 I_1/N_p 1.20 I_1/N_p	0.5 I_1/N_p	1.57 I_1/N_p I_1/N_p † †	1:1.4
48	Resistance Inductance Battery Capacitance	1 125 1 125 0.8 *	0.80 I_1/N_p 0.80 I_1/N_p 1.20 I_1/N_p 1.20 I_1/N_p	0.5 I_1/N_p	1.57 I_1/N_p I_1/N_p † †	1:1.0
18	Resistance Inductance	1.49	0.60 I_1/N_p 0.60 I_1/N_p	0.333 I_1/N_p	1.21 I_1/N_p I_1/N_p	1:1.0
4	Resistance Inductance	0.74	0.60 I_1/N_p 0.60 I_1/N_p	0.333 I_1/N_p	1.05 I_1/N_p I_1/N_p	1:1.0
4	Resistance Inductance	1.49	0.30 I_1/N_p 0.30 I_1/N_p	0.167 I_1/N_p	0.525 I_1/N_p 0.500 I_1/N_p	1:1.4
4	Resistance Inductance	1.28	0.42 I_1/N_p 0.42 I_1/N_p	0.167 I_1/N_p	1.05 I_1/N_p I_1/N_p	1:1.4

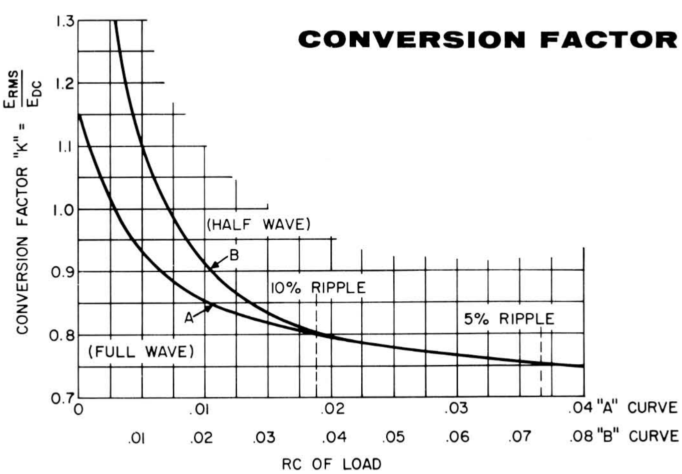


Figure 1.

CONVERSION FACTOR VS RC OF LOAD (60 CYCLES)

Notes: (1) RC—Load resistance in ohms times capacitance of load in Farads.

Calculate $R = \frac{VDC}{IDC}$ if unknown

(2) If input line frequency differs from 60 cps, convert RC of load to equivalent RC by multiplying RC (actual) by $\frac{F}{60}$, where F is applicable frequency. Then use RC (equivalent) in Fig. 1 to obtain K.

(3) If RC exceeds values in abscissa use K 0.73.

2. VOLTAGE-RATING SYMBOL ____________
CELL-VOLTAGE RATING ____________ RMS

Obtain this data from the following table, choosing the cell-voltage rating which most nearly satisfies the condition. In some cases it may be advisable to work out solutions with each type cell.

When These Conditions Prevail			Select One Symbol and Corresponding Rating	
Life Expectancy Is Between	Amb. Temp Range Is	And Load Current Is (Approx)	Symbol	Cell Rating
1,000 to 60,000 hr.	110°C to 35°C or less	Up to 0.625 amp.*	P	45 Volts (rms)
1,000 to 70,000 hr.	120°C to 35°C or less	Any Value	L	36 Volts (rms)
1,000 to 80,000 hr.	130°C to 35°C or less	Any Value	G	26 Volts (rms)

*Half-wave rating per cell for 60,000 hr. life @ 35°C ambient.

3. NUMBER OF SERIES CELLS REQUIRED PER ARM (N_s)

$$N_s = \frac{\text{Voltage Required (From Data)}}{\text{Voltage Rating per Cell}} = \_\_\_\_\_\_ = ‡\_\_\_\_\_\_$$

‡When N_s is not a whole number use next higher whole number.

Referring to Table 2 Cell Voltage Ratings (below), select the voltage rating per cell corresponding to the circuit and load conditions and enter as denominator Be sure to use the cell DC output rating if numerator is given as output voltage, or use cell-input AC rating if the input requirements are given.

TABLE 2—CELL VOLTAGE RATINGS AT RATED CURRENT & 35°C AMBIENT

Maximum AC Volts Input Rating per Cell						Peak Inverse Volts	DC Volts Output Rating (Maximum, Aged) per Cell		
Resistive Loads				Bty. & Cptv. Lds.					
Circuit	Circuit Symbol	Line To Line	Line To Neutral	Line To Line	Line To Neutral		Resistive Loads	Battery Load	Capacitance Load
SINGLE-PHASE, 26 VOLTS/CELL (VOLTAGE RATING SYMBOL G)									
Half-Wave	H	26		13		37	10.5	13.5	(Up to) 17
Center Tap	C		13		13	37	9.5	13	(Up to) 16
Doubler	D			13		37			(Up to) 31.5
Bridge	B	26		26		37	19	28.5	(Up to) 31.5
THREE-PHASE 26 VOLTS/CELL (VOLTAGE RATINGS SYMBOL G)									
Half-Wave	Y	26		16		37	14.5	8	8
Full Wave C.T	S	22.5		22.5		37	14	14	14
C.T (with interphase)	S	26		26		37	14.5	14.5	14.5
Bridge	F	26		26		37	29.5	29.5	29.5
SINGLE-PHASE 36 VOLTS/CELL (VOLTAGE RATING SYMBOL L)									
Half-Wave	H	36		18		51	14.5	19	(Up to) 23.5
Center Tap	C		18		18	51	13.5	19	(Up to) 22.5
Doubler	D			18		51			(Up to) 45
Bridge	B	36		36		51	27	40.5	(Up to) 44.5
THREE-PHASE 36 VOLT/CELL (VOLTAGE RATING SYMBOL L)									
Half-Wave	Y	36		22		51	21	11.5	11.5
Full Wave C.T	S	31		31		51	20.5	20.5	20.5
C.T. (with interphase)	S	36		36		51	21	21	21
Bridge	F	36		36		51	42	42	42
SINGLE-PHASE 45 VOLT/CELL (VOLTAGE RATING SYMBOL P)									
Half-Wave	H	45		22.5		63	18.5	24	(Up to) 29.5
Center Tap	C		22.5		22.5	63	17.5	24	(Up to) 28.5
Doubler	D			22.5		63			(Up to) 57
Bridge	B	45		45		63	35	47.5	(Up to) 57
THREE-PHASE 45 VOLT/CELL (VOLTAGE RATING SYMBOL P)									
Half-Wave	Y	45		27.5		63	27	15.5	15.5
Full Wave C.T	S	39		39		63	26.5	26.5	26.5
C.T (with interphase)	S	45		45		63	27	27	27
Bridge	F	45		45		63	54.5	54.5	54.5

NOTE: The d-c voltage ratings in this table have been selected to hold the cells at their respective maximum peak inverse voltage ratings.

4. TOTAL CELLS REQUIRED

(Number of Arms) (Number of Series Cells) = ____________

Obtain information from steps 1 and 3.

5. EQUIVALENT CURRENT RATING (ECR)

$$\text{ECR} = \frac{\text{Load current}}{\text{Current Index}} = \_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_$$

Use Load Current from DATA. Select Current Index according to which of the following conditions apply Multiply Current Index by 0.8 for capacitive loads.

I. CONVECTION COOLED

(a) For continuous current, maximum life (60-80,000 hours) 35°C Ambient, use current index = 1.0.

(b) For continuous current, less than maximum life and/or above 35°C ambient, use the life required and/or ambient temperature involved, select the current index which pertains to these conditions from the curves below Observe the voltage rating symbol which has been selected in Step 2.

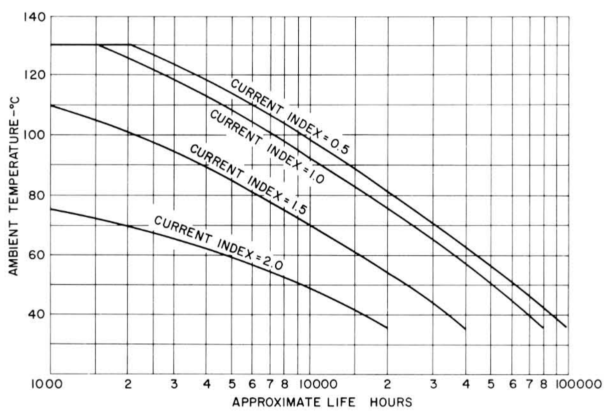


Figure 2. *Voltage Rating (Symbol G)†*

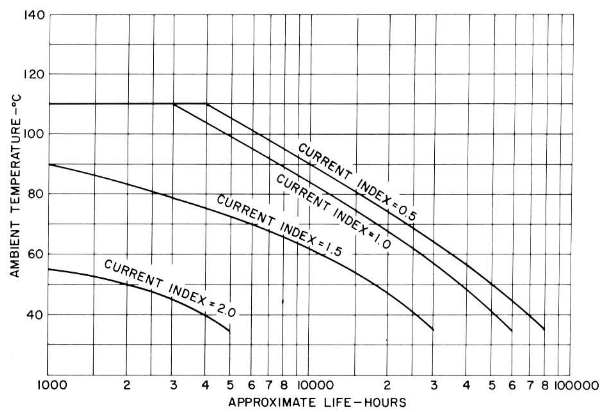


Figure 3. *Voltage Rating (Symbol P)†*

†For 36 volt cells (Symbol L); to find current index, take readings from Figure 2 and Figure 3 at same life and temperature and use average value.

(c) Intermittent current, maximum life expectancy, 35°C ambient, select current index from Figure 4.

NOTE: This curve does not apply to surge currents superimposed on steady state currents. This assumes current falls to zero at end of surge.

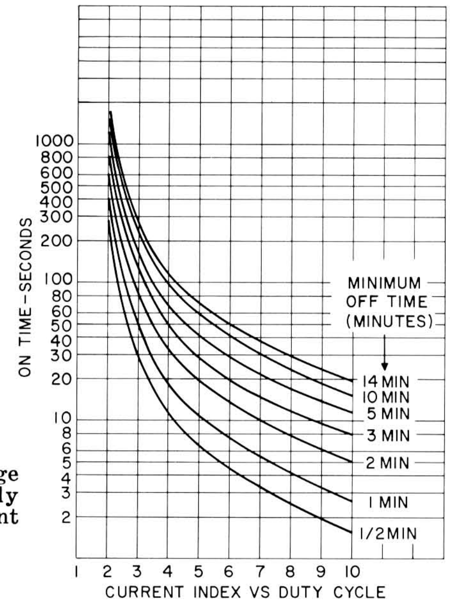


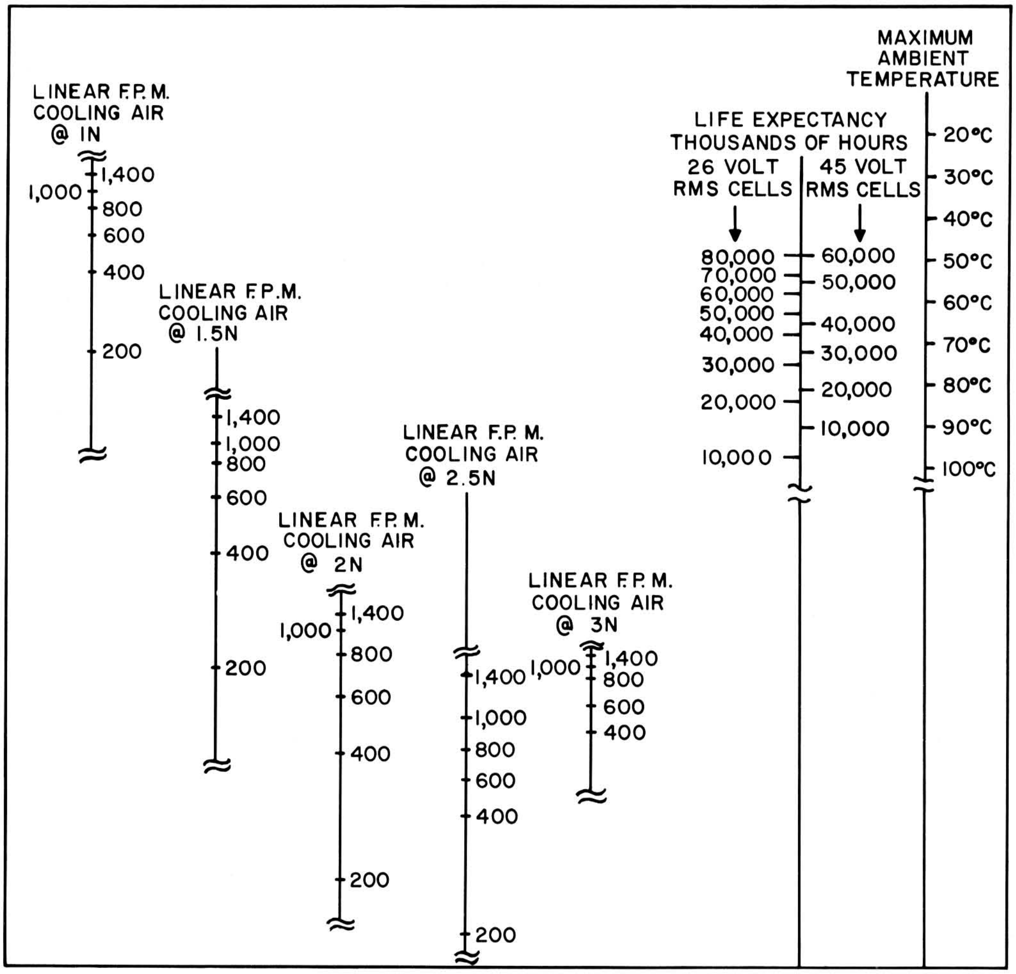
Figure 4. *Current Index vs Duty Cycle*

II. FORCED-AIR COOLED

Select a current index from the following nomograph by placing a straight edge connecting the points of the specified Life and Temperature and determine which vertical current index line intersects the straight edge nearest to the specified air velocity

FORCED-AIR COOLING

Life Expectancy vs Air Temperature and Velocity as a Function of Current Density



(1) Normal current rating of rectifier (N) for forced air cooling is the short stack rating as given in Table No. 3, Page 22.

(2) 1400 linear feet per minute is optimum cooling air velocity

(3) To obtain Approximate Life Expectancy when using 36 V-RMS cells, take average at 26 and 45 V-RMS life for same conditions.

Nomograph

6. CELL-TYPE NUMBER

Using the equivalent current rating calculated in step 5, select from Table 3 the cell which most nearly corresponds to this value. Observe the rating which corresponds to the number of cells in step 4.

NOTES:

(a) If the application is forced-cooled, use the short stack rating which is the maximum rating for the circuit involved.

(b) If the total number of cells from step 4 exceed the maximum allowed for the selected cell, divide the total into smaller groups.

Each group will become a separate rectifier containing an allowable number of cells. It may also be necessary to reconsider the type of construction using the type which will accommodate the maximum number of cells. The following is a suggestion on how a subdivision may be made

Single-phase circuits

(1) Half wave — two or more equal stacks

(2) Center tap or doubler — even number of equal half-wave stacks

(3) Bridge — two equal doubler stacks or multiples of four half-wave stacks

Three-phase circuits

(1) Half wave—multiples of three equal half-wave stacks

(2) Bridge — three equal doubler stacks or multiples of six equal half-wave stacks

Note: Enter the number of rectifiers required to make up the required number of cells in step No. 10.

(c) If the ECR is greater than the rating of the largest cell, one or more parallel cells will be required. Simply divide ECR by successive whole numbers until the optimum combination of whole numbers and the nearest rating of the largest cell is reached. Record the whole number in step 9 over "parallel cells." Multiply total cells in step 4 by this number It may be necessary to reduce the rectifier into multiple rectifiers to accommodate the total number of cells.

TABLE 3—CELL CURRENT RATINGS AT 35°C AMBIENT

(Resistive loads; derate 20 percent for capacitive loads)

Cell Type & Size →	No. 6 5/32-inch Diameter (.0134 Active Area)			No. 5 9/32-inch Diameter (.0497 Active Area)			No. 20 15/32-inch Diameter (.155 Active Area)		
No. of cells in Stack									
Clip	1-6			1-6			1-6		
Half-Wave Tube	1-30	31-100	101-250	1-30	31 100	101-250	1-30	31 100	101-230
Slotted Tube	1-30	31-96		1-30	31 100	101 116			
Metal				1-30	31-40		1-30	31-40	
Rated Current	ma	ma	ma	ma	ma	ma	ma	ma	ma
Single Phase									
Half Wave or Doubler	2.5	2.0	1.5	8.0	6.0	5.0	25.0	11.0	7.0
Full Wave Center Tap	5.0	4.0	3.0	16.0	12.0	10.0	50.0	22.0	14.0
Full Wave Bridge	5.0	4.0	3.0	16.0	12.0	10.0	50.0	22.0	14.0
Three Phase									
Half Wave	7.5	6.0	4.5	24.0	18.0	15.0	75.0	33.0	21.0
Full Wave Bridge	7.5	6.0	4.5	24.0	18.0	15.0	75.0	33.0	21.0
Full Wave Center Tap	11.0	8.8	6.6	35.2	26.4	22.0	110.0	48.4	30.8
Full Wave C.T (I.P.T.)	15.0	12.0	9.0	48.0	36.0	30.0	150.0	66.0	42.0
D-C Circuit Value	3.0	2.4	1.8	9.6	7.2	6.0	30.0	13.2	8.4

Cell Type & Size →	No. 21 1-inch Square (0.59 Active Area)			No. 22 1½-inch Square (1.68 Active Area)			No. 25 2-inch Square (3.01 Active Area)		
No. of cells in Stack									
Stud	1-12	13-24	25-40	1 12	13-24	25-40	1-12	13-24	25-40
Eyelet	1-8			1-8					
Tube	1-12	13-18		1-12	13-18		1-12	13-16	
Rated Current	amps	amps	amps	amps	amps	amps	amps	amps	amps
Single Phase									
Half Wave or Doubler	0.150	0.120	0.090	0.360	0.310	0.265	0.625	0.55	0.475
Full Wave Center Tap	0.300	0.240	0.180	0.720	0.620	0.530	1.25	1 10	0.95
Full Wave Bridge	0.300	0.240	0.180	0.720	0.620	0.530	1.25	1 10	0.95
Three Phase									
Half Wave	0.450	0.360	0.270	1.080	0.930	0.795	1.87	1.65	1.42
Full Wave Bridge	0.450	0.360	0.270	1.080	0.930	0.795	1.87	1.65	1.42
Full Wave Center Tap	0.660	0.530	0.400	1.580	1.360	1 170	2.75	2.42	2.10
Full Wave C.T (I.P.T.)	0.900	0.720	0.540	2.160	1.860	1.590	3.75	3.30	2.85
D-C Circuit Value	0.180	0.144	0.108	0.432	0.372	0.318	0.750	0.660	0.570

Cell Type & Size →	No. 14 3⅜-inch Round (7.52 Active Area)			No. 15 4⅜-inch Round (13.34 Active Area)			No. 31 4¼-inch x 6-inch (21.4 Active Area)			No. 32 5-inch x 6-inch (27.5 Active Area)		
No. of cells in Stack												
Stud	1-12	13-24	25-36	1-8	9-16	17-28	1-8	9-16	17-24	1-8	9-16	17-24
Rated Current	amps	amps	amps	amps	amps	amps	amps	amps	amps	amps	amps	amps
Single Phase												
Half Wave or Doubler	1.50	1.35	1.20	2.60	2.35	2.10	4.00	3.7	3.4	5.0	4.7	4.4
Full Wave Center Tap	3.00	2.70	2.40	5.20	4.70	4.20	8.00	7.4	6.8	10.0	9.4	8.8
Full Wave Bridge	3.00	2.70	2.40	5.20	4.70	4.20	8.00	7.4	6.8	10.0	9.4	8.8
Three Phase												
Half Wave	4.50	4.05	3.60	7.80	7.05	6.30	12.0	11 1	10.2	15.0	14.1	13.2
Full Wave Bridge	4.50	4.05	3.60	7.80	7.05	6.30	12.0	11 1	10.2	15.0	14.1	13.2
Full Wave Center Tap	6.60	5.95	5.30	11.40	10.30	9.20	17.6	16.3	15.0	22.0	20.7	19.4
Full Wave C.T (I.P.T.)	9.00	8.10	7.20	15.60	14.10	12.60	24.0	22.2	20.4	30.0	28.2	26.4
D-C Circuit Value	1.80	1.62	1.44	3.12	2.82	2.52	4.8	4.3	4.1	6.0	5.6	5.3

7. CURRENT DENSITY RATIO (CDR)

$$CDR = \frac{\text{Load Current}}{\text{NEMA Current Rating}} = \_\_\_\_\_\_ = \_\_\_\_\_\_$$

Obtain NEMA current rating of cell (selected in Step 6) from Table No. 3. The NEMA rating of the cell is shown in bold type.

Note: The following curves are for design purposes only.

V_d = Cell Voltage Drop = ______

(V_d) is obtained from following curves. Be sure to observe proper voltage-rating symbol, continuous or intermittent current and ambient temperature rating.

FOR CONTINUOUS LOAD – 30°C AMBIENT†

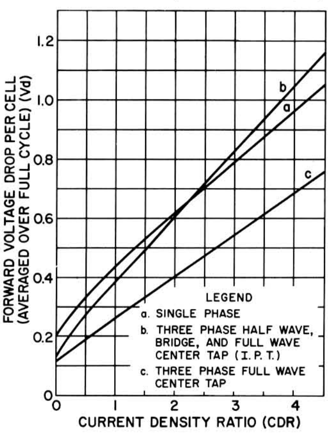


Figure 5.

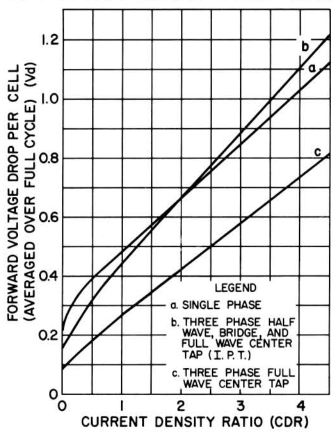


Figure 6.

FOR INTERMITTENT LOADS AT 30°C AMBIENT†

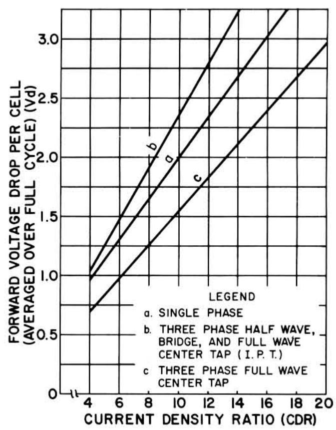


Figure 7.

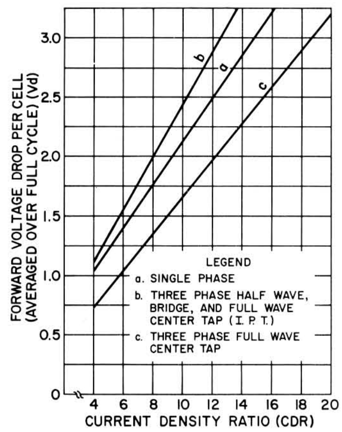


Figure 8.

†For ambient temperature differing from 30°C see Figure 9 below:

FOR AMBIENT TEMPERATURES ABOVE OR BELOW 30°C, USE THE FOLLOWING CURVE TO CORRECT THE V_d VALUES AS SHOWN IN FIGURES 5-8 ABOVE.

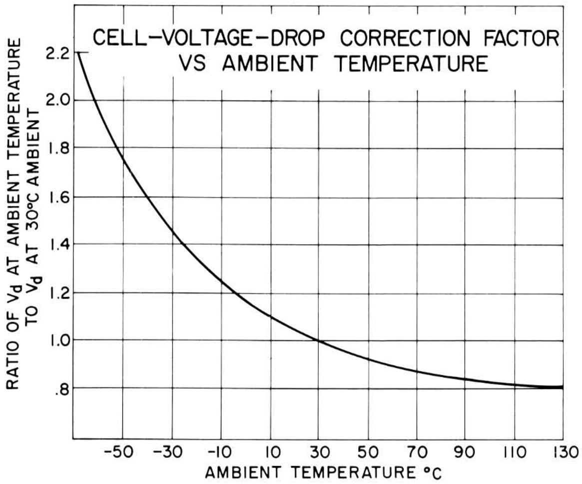


Figure 9.

8A. INPUT OR OUTPUT REQUIREMENTS (NEW)

(a) AC Volts Input (rms) $= K\,[VDC + (C)(N_s)(V_d)]$

(b) DC Volts Output $= \dfrac{VAC\ (rms)}{K} - [(C)(N_s)(V_d)]$

8B. INPUT OR OUTPUT REQUIREMENTS (AGED)

(a) AC Volts Input $= K\,[VDC + 2(C)(N_s)(V_d)]$

(b) DC Volts Output $= \dfrac{VAC\ (rms)}{K} - [2(C)(N_s)(V_d)]$

Values of C, N_s, V_d and K are obtained from preceding steps, VAC or VDC from Data; solve for unknown voltage. Note that VDC for doubler circuits must be divided by 2 in the calculations in order to determine the proper applied voltage.

To indicate how these data are used, assume that it is desired to determine the AC voltage required to obtain 100 volts DC from a single phase bridge rectifier supplying a resistive load and operating at a current density ratio of one.

From Table 2, page 18, it may be seen that the DC volts output rating for a 26 volt cell in a single phase bridge circuit is 19 volts DC. Hence, six 26 volt cells (100 ÷ 19) will be used in series in each leg of the bridge. From Fig. 5, Section 3, the average drop per cell at CDR = 1 is Vd = 0.437 volts. From Table 1, page 16 K = 1.125 and C = 4. Using 8A (a), above, the required AC input is

AC volts input (rms) $= 1\,125\,[100 + (4)(6)(0.437)] = 124.3$

It should be pointed out that this calculation covers only the new condition and assumes the use of average cells. The voltage drop will approach twice this value as the rectifier ages and the value could vary ±20% due to the variation found in the rectifier's forward resistance.

Just as the voltage relations in a practical circuit differ from those calculated, so do the current relations. Again referring to Table 1, it is shown that there is a specified ratio of IAC/IDC for each circuit and load condition. These are empirical values determined from actual data.

9. MODEL NUMBER

6RS ______	______	______	______	______	______	______
Cell Type (Step 6)	Voltage Symbol (Step 2)	Circuit Symbol (Step 1)	Series Cells (Step 3)	Construction Details (See Reverse Side of Work Sheet)	Finish	Parallel Cells (Step 6)

The reverse side of ECG-344-1 (page 13) defines the number of cells and the types of construction available for each cell size. Be sure to check this information carefully to avoid the creation of an impossible combination. If it was necessary to break down the total number of cells into multiple rectifiers, there probably will be a change required on the original circuit symbol. For example, if a full wave bridge rectifier will be made up of four half wave stacks, the model number of the stack will contain a symbol "H" not B.

10. QUANTITY REQUIRED

Order number of rectifier stacks required per supply__________

Signed ______________________________

Location ______________________________

GENERAL ELECTRIC

SEMICONDUCTOR PRODUCTS DEPARTMENT

ECG-344A 9/59

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