

# PLATING RECTIFIERS

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Today's rectifier operates on the same principles used for decades. Sure, there have been many incremental improvements in manufacturing methods and materials, but the basic principles are the same. The most noteworthy improvements are those associated with electronics and computerisation. All rectifiers have 1) a transformer that lowers Eskom's high voltage to the 6–18 volts normally used by electroplaters or to the somewhat higher voltages required by anodisers; 2) a rectification system that changes alternating current (AC) to direct current (DC); 3) power regulators; 4) controls and 5) a means of cooling these components. Other than the cooling section, there are no moving parts.

## TRANSFORMERS

A transformer has primary and secondary sets of magnetic cores wound with conductive wire. The ratio of the number of wire turns around the primary versus the number around the secondary regulates how much the voltage is stepped down. For example, if the primary has 400 turns and the secondary 10 turns, the ratio is 40:1. Therefore if the input to the primary is 400 v, the secondary's output is 10 v ( $400/40$ ). Most common plating processes require 6-18 v, and rectifiers producing this at amperages of 50 - 10,000 or more are readily available.

## RECTIFICATION AND CONTROL

AC produces a wave on an oscilloscope that oscillates above and below the horizontal. The rectifier "filters out" the lower portion of the wave, as shown in Fig. 1a. This is "half-wave rectification." It pulsates. Fig. 1b shows full-wave, single-phase rectification, which still has pulsation, but at closer intervals. Fig. 1c shows full-wave, three-phase rectification. It still has slight pulsation, but there is a variation (ripple) of less than 5%, and that is satisfactory for most (not all) electroplating processes.

The modern rectifier uses a semiconductor (usually silicon) to "filter out" the

AC and allow only DC to flow through it. The simplest of these devices is known as a “diode.” Silicon also can be part of controlling a rectifier. These devices are known as “thyristors” or “silicon-controlled rectifiers” (SCR). They are basically diodes, but require a control signal at a terminal or “gate.” They are used both for rectification and regulation of output, depending on the design.

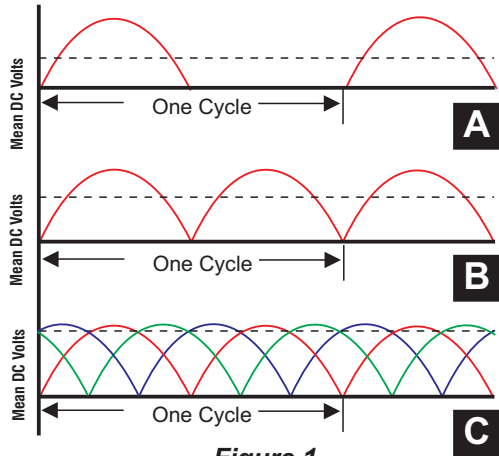


Figure 1

The difference is in whether the SCR is used on the primary or secondary side of the transformer. There are good reasons for either design, based upon your applications, the unit’s efficiency, reliability and cost. Your rectifier supplier should consider your needs and explain which will work better for you and why.

## RIPPLE

A problem with SCRs is that they produce DC distorted by “ripple” - the remainder of the fluctuating AC sine wave. Most larger rectifiers produce ripple of five percent or less at rated capacity. Operating a rectifier at far less than its capacity is not a good idea, since ripple increases as the unit is powered down. Plating chromium, precious metals, alloys and certain other metals requires minimum ripple, and if ripple is too high, it’s easy to add a ripple filter that smoothes the wave. Ripple is not very important in electrocleaning, electropolishing and anodising.

## OTHER CONTROL METHODS

The tap switch is a simple alternative to solid-state controls. It relies on switching between varying numbers of wire windings on the primary and secondary transformer sections. If, for example, one has 400 windings on the primary and 10 on the secondary, with an output of 12 v, voltage will be cut to six if the windings on the primary are doubled to 800. A switch contacting larger or smaller numbers of windings on the primary controls the voltage. A tap-switch control produces DC with less than five percent ripple regardless

of the output voltage. A disadvantage, however, is that voltage fluctuations are normal, a problem if plating thickness is critical. A similar control is the variable autotransformer, which works on the same principle, but has no “taps,” and is continuously variable.

### **SWITCH-MODE POWER**

Another type of rectifier is the switching transistor-type. An EMI filter rectifies and filters incoming line power to produce DC. An inverter changes it back to AC at approximately 1,000 times the line frequency. This high-frequency AC is then stepped down to plating voltages, and rectified and filtered again to produce a high-current, low-voltage output, with very low ripple. Plating voltages and amperages come from a totally sealed, water-cooled enclosure. The small footprint and light weight allow it to hang on a wall or fit where conventional units won't.

### **COMPUTERISATION**

The most striking technology changes have been those made possible by electronic components—microprocessors, computers, etc. Rectifiers with digital controls regulate amperage and voltage more precisely. They allow the current to be “ramped up” as the parts enter plating or anodising tanks, and turned off at precisely the right times. They can provide pulse plating, control ampere-hours, reverse current, and be programmed for complex wave forms. They may have computer interfaces. computerisation (some of it from personal computers equipped with special software) and microprocessors can control a number of rectifiers, the movements of hoists and conveyors, additions of brighteners and other chemicals, solution temperatures, agitation and other variables. You can apply exactly the thicknesses of metals specified, in the sequence desired, time after time. computerisation tells the operator at a remote location when something isn't right. That cuts costs, reduces rejects, produces a part that is the same every time, and eliminates labour. The computer can control power so exactly that none is wasted, thus cutting power bills. Its memory records what has been done to each part and under what conditions. If there is a reject, it's easier to trace what happened.

### **ANODISING**

Anodisers use rectifiers very similar to those used by electroplaters, except

that higher voltages are required—as high as 150v for hard-coat anodising. Some color-anodising processes such as electrolytic colouring require AC power supplies (still referred to as “rectifiers”) as well as DC and instrumentation that allow adjusting voltages and positive-negative cycles rapidly and according to a predetermined program.

### **PULSE PLATING AND PERIODIC REVERSE**

Pulse plating involves application of rapidly cycled interrupted direct current. It may be combined with periodic reverse, in which the current is cycled between forward and reverse, for preset times in each direction. In electronics applications pulse plating produces deposits that are denser, have finer crystal structure, can be applied more rapidly, are smoother, and require less plating-solution additives. Rectifiers for these applications are programmable for a range of currents measured in milliamps to perhaps 1,000 amperes, delivered as forward, reverse or pulsed current, or combinations thereof. They are more expensive, but so is gold. Pulse plating and interrupted-current techniques have moved beyond the electronics industry to such applications as electropolishing, anodising, electrocleaning and barrel plating.

### **RECTIFIER PLACEMENT**

The rectifier should be as close as possible to the plating tank. The farther away, the longer the bus runs and the greater the current losses and maintenance. The problem is that you have to cool the rectifier components to prolong their life, and if the rectifier is air cooled, it may be drawing in corrosives, shortening its life. Sometimes the problem can be solved by installing the rectifier on the other side of a nearby wall. The controls can still be next to the plating station. But if that’s not feasible, there are air-tight water-cooled units, either direct or heat-exchange. Rectifiers are rated to be operated at certain maximum temperatures, and if the ambient air exceeds those temperatures, water cooling may be mandatory.

### **MAINTENANCE AND REPAIR**

Rectifiers have no moving parts other than the fans or pumps used for cooling. Properly installed and operating at prescribed temperatures, they should last for a long time. As with any other piece of equipment, regular


maintenance pays. Change or clean air filters regularly and keep away boxes or other items that interfere with air flow. Be sure that fan blades are secure. Maintain water pumps and filters. Keep semiconductors and heat sinks clean to aid in cooling. Check all the control instrumentation - buttons and lights, etc. - regularly, and replace if necessary.

Rectifiers often have onboard diagnostics that show trouble spots on their digital displays. Ammeters, voltmeters and oscilloscopes help to isolate troubles. You don't have to be an electrical engineer to repair a rectifier, but you do have to understand electrical equipment and be aware of the dangers of high voltages and currents. Suppliers of rectifiers provide detailed manuals and parts lists to aid in repairing and minimising downtime.

### **BUYING A RECTIFIER**

You know some of the things you like about the rectifiers you have now. Your chemical supplier may suggest features that would improve the processes used in your shop. Hopefully this brief article triggers thinking about other ideas you'd like to explore. What makes a good rectifier? What should you look for when considering a purchase? According to Ray Dargis<sup>1</sup>, the list includes -

- ☑ Reliability
- ☑ Repeatability
- ☑ Conversion Efficiency
- ☑ Low Maintenance Costs
- ☑ Excellent Warranty
- ☑ Ease of Installation
- ☑ Expandability

You can't look inside a rectifier to see its superior qualities. Most innards look alike. But there are some important choices in manufacturing materials and methods hidden in those cabinets. Your job is to establish trust with your supplier, and possibly to ask your fellow platers about their experiences. You may want to add to the above list your own "wish list" of items that would improve your ability to produce a quality finish with ease and assurance, and to do some things you can't do now. 

<sup>1</sup>*Pretreatment for Electroplating, by Ray Dargis, page 11, 2006 PF Directory.*