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Effects of Heat & Humidity

Heat and humidity are the worst enemies of the rectifier in a typical finishing environment. Ambient conditions, and other conditions, change through the year in the finishing facility. How do these conditions affect the rectifier, and what is the best way to deal with them?

The Problems Heat Can Cause

Heat is endemic to the rectifier and the process, and is exacerbated by the weather at various times of the year or different parts of the country. Most of the functional components of a rectifier (*e.g.,* diodes, SCRs, tapswtiches, and the main transformer) have various levels of inefficiency. Consequently, the more inefficient a component and the more current it conducts, the more heat it generates inside the rectifier. When this generated heat is added to ambient heat, the combined effect may stress the following components:

- **Main Transformer**—As one of the biggest heat sources within a rectifier, much of the heat generated deep in the center of the transformer is difficult to remove. The heat must be transferred conductively from the center to the outside of the transformer, where it can be removed either by radiation (or convection if it is air-cooled) and by transfer to a fluid (if it is fluid cooled). The design and efficiency of the transformer varies significantly between manufacturers and should be a significant consideration at purchase. Dirt build-up in an air-cooled rectifier and lime or sludge build-up in a water-cooled rectifier can have a huge effect on the efficiency of the cooling method employed. Even if the transformer has over-temp thermals to protect the transformer from a catastrophic failure, the long-term effect from overheating can break down the insulation between the primary coils and lead to premature failure. Designs with the transformer immersed in an oil bath avoid the dirt build-up issue but must still contend with the aggregate thermal considerations.
- **SCR and Diode Stacks**—Design plays a significant part in the efficiency of these components and can vary significantly between manufacturers. If the heat sink does not have sufficient area or if it's not situated optimally for heat removal then heat build-up can either trip the over-temp thermals or damage the semi-conductors to the point where they prematurely fail. Another contribution to inefficiency is the selection of the semi-conductors themselves. Different brands or different grades of SCRs and diodes will generate more heat than others. This is where you need to depend on past experience and a reputable manufacturer to avoid this particular problem. As with the main transformer, dirt or lime build-up will reduce the efficiency of heat transfer.
- **Circuit Boards & Other Components**—Circuit boards, terminal strips, relays, thermals, and other electric or electronic components are susceptible to the build-up of corrosion or dirt, particularly if the dirt has metallic oxides and humidity has saturated the material. Short circuits may occur and cause immediate failure of the components, misfiring of the SCRs, failure of the rectifier to start, etc.

Solutions

There are a variety of solutions, depending on the circumstances and contributing factors:

- **Air-Flow**—All fans should be checked for proper operation. Are they running at the correct RPM and are the fan blades in good shape? Are any screens or shrouds obstructing air flow? Is debris either inside or outside the rectifier obstructing air flow? Any conditions that are not acceptable should be corrected. If additional air-flow is necessary, it may be possible to change the fan blade design and increase the RPM or horsepower of the motor.
- **Water-Flow**—This should be verified per the specifications of the manufacturer, specifically the temperature range for the incoming water and the necessary flow in gallons per minute (GPM), to ensure proper cooling. If the incoming water is not cool enough, it may be necessary to add a chiller to the system. If the flow is insufficient, you will need to check the interior of the cooling lines that run throughout the rectifier. If the lines are obstructed by deposits, they will need to be removed by flushing the system, usually with a mild acid solution. Another potential source is the solenoid system that allows the cooling water into the rectifier. You will need to verify that the thermals that energize the solenoid are functioning and that the solenoid itself is functioning correctly. Be aware that removing a solenoid and allowing constant water flow can create a number of problems with condensation dripping on electrical components, as well as wasting water.
- **Dirt and Corrosion**—A build-up of dirt or excessive corrosion on a heat sink or other surface that depends on radiant or convection transfer of heat, will reduce the cooling efficiency. Removal of the material can often be done with compressed air, a stiff brush, or in the case of an oily residue, an appropriate solvent. You may wish to consult the manufacturer to determine their recommendation for cleaning. In severe cases, component replacement may be necessary. The point to stress is that the interior of the rectifier must be inspected periodically and cleaned when necessary. The

frequency of cleaning will depend on the ambient conditions, which includes the amount of dirt in the air as well as the temperature in which the unit will be operating in.

- **Rectifier Placement**—The common practice of placing rectifiers adjacent to the finishing line can have negative consequences, particularly if the rectifier is air-cooled. The high CFM of the cooling fans in rectifiers will draw through the unit the type of corrosive material you least want in a high-voltage piece of equipment. The finishing line is also a source of additional heat to further stress the rectifier. Another common practice is to place rectifiers on a mezzanine above the finishing line. This has the added disadvantages of higher temperatures and increased probability of drawing fumes into the unit. When it is possible to construct a separate rectifier enclosure and provide it with a source of clean, dry, and preferably cool air, you will add immensely to the reliability of your rectifier.
- **Rectifier Thermals**—Thermals are generally of two types—over-temp thermals and solenoid thermals.

  Over-temp thermals are wired with the start or stop button on the rectifier so that any over-temp condition will shut the unit off. There may be several of these placed in various locations within the rectifier.

  Solenoid thermals are used to activate a water solenoid, and are wired so that any location that reaches the minimum temperature to require cooling water will activate the solenoid. Regardless of the type, dirt and condensation can short out the 110 VAC used on these thermals to the surface they are mounted on. A periodic inspection will reveal when there is such a build up so it can be removed. ***P&SF***