

## ELECTROMAGNETIC RADIATION SAFETY AND RF HEAT SEALERS

The properties of electromagnetic energy have always lent themselves well to sealing plastics. Just as a microwave oven heats food, an RF heat sealer heats a plastic part to the point at which it can bond with another plastic part or to another surface. The technique is faster and cleaner than conventional thermal welding, and produces a stronger bond as well. It's not surprisingly that there are more than 100,000 RF heat sealers in operation in the US throughout many industries.

As with any system that generates high levels of electromagnetic energy, there are potential safety problems associated with their operation. When designed, operated, and maintained properly, the systems produce extremely low levels of radiation in the vicinity of the operator, well within the guidelines set forth in the latest nonionizing (electromagnetic) radiation safety standard – IEEE C95.1-1991 – which has been adopted by many regulatory agencies and the American National Standards Institute (ANSI).

However, if the shields designed to protect the operator from overexposure conditions are not properly deployed, if the shields are in some way defective, or if the design of the heat sealer does not pay attention to shielding, the level of

radiation to which the heat sealer operator may be exposed can be *orders of magnitude* higher than that considered safe. Clearly, the potential for severe overexposure exists (see *The Impact of Shield Failure, page 121*).

### THE EXPOSURE ENVIRONMENT

During most of the time that RF heat sealers have been used, there was little attention paid to overexposure of workers to RF radiation. However, much more is known today about the effect of RF radiation on the human body at certain levels of exposure.

Unlike the alleged damage caused by exposure to the minuscule levels of RF radiation produced by computer monitors and display terminals, exposure to the potentially immense radiation emitted by a faulty RF heat sealer will very likely produce heating of tissue, which at the very least can cause flu-like symptoms.

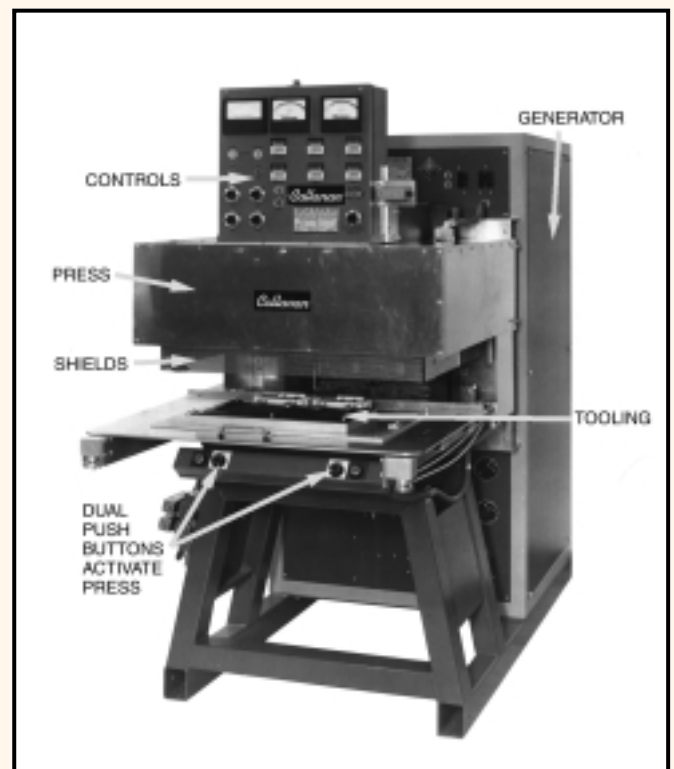
To put these different levels in perspective, the amount of power generated by a video display terminal (VDT) might be several microwatts (millionths of a watt). The power generated by an RF heat sealer is between 1500 W to more

### HOW RF HEAT SEALERS WORK

RF heat sealers are relatively large industrial machines that have an RF generator within them. The generator is comprised of three basic components — a power supply, oscillator, and controls. The power supply converts the line power source into high-voltage direct current.

The oscillator circuit converts this power into RF energy, generally at a frequency of 27.12 MHz, although other frequencies are sometimes used. This frequency is one of the Industrial, Scientific, and Medical (ISM) frequencies designated by the Federal Communications Commission (FCC) for unlicensed operation. The controls regulate and monitor the operation of the sealer as it heats the seal area. The RF is applied to the work via an applicator, which is generally an air-operated press with interchangeable electrodes that vary in shape with the area to be sealed.

The operator typically places the item to be sealed on the applicator and then begins the sealing process by simultaneously pressing two switches. The two switches are used to ensure that the operator both hands free of the press. Once the switches are activated, the press and shields begin to close. Once the press has applied the proper amount of pressure, the RF generator comes on and the heating cycle begins. Heating time is typically a few seconds and then the generator is shut off and the press and shields open, and the sealer is ready to accept another part.



## Application Notes

than 60,000 W – the same level as produced by many radio and television broadcast transmitters. While the power radiated by a broadcast antenna is emitted at a point far from human contact, the RF heat sealer generates its power within a few inches of the operator.

Compounding the problem is that many RF heat sealers in use today could not meet IEEE C95.1 even if operating as designed. This is because this equipment was designed and manufactured before strict attention was paid to non-ionizing radiation in the workplace. Sadly, even some new RF heat sealers currently being sold will also not comply with the exposure limits imposed by IEEE C95.1-1991.

Finally, even the best of the new equipment can still produce serious overexposure should the shields fail. They are mechanical and must be removed or adjusted with every change of tooling. In some work environments, in which the operators are paid by the piece, it is not uncommon for operators to remove the shields that have just been inspected by a supervisor or health and safety professional in order to increase their production rates. When this is done, the operator is subject to severe overexposure conditions.

### THE RAMIFICATIONS

From a liability standpoint, the potential damage to employees from overexposure to high levels of radiation emitted from RF heat sealers can be menacing. This is especially true today, when more and more people are becoming aware of rights in the workplace and sensitivity to workplace hazards is increasing.

To ensure compliance with current standards as well as to provide employees with a safe working environment, several steps must be taken. None of these steps is necessarily expensive or requires large amounts of time. However, all require a consistent, long-term commitment to something called an RF Radiation Safety Program. These programs are more important than ever because IEEE C95.1-1991 is much more restrictive than earlier standards and essentially makes a high percentage of RF heat sealers now in service dangerous and obsolete (see *Putting the Heat On Sealers*, page 122).

### THE ELEMENTS OF AN RF PROTECTION PROGRAM

An RF Radiation Safety Protection Program serves several purposes. First, it establishes the company as being concerned about the health and safety of its employees. While it does not eliminate liability, a well-administered, well-documented program goes a long way toward creating a safe environment for employees, potentially reducing liability in case of litigation, and appeasing OSHA and state and local government agencies.

However, it is important to note, that a poorly-planned, sloppily-administered program may be as bad as having none at all, or sometimes worse, since it produces a tale of indifference. OSHA inspectors and lawyers may know just what questions to ask in order to determine the efficacy of any RF Radiation Safety Program.

Simply constructing a program, producing documentation, and then ignoring it, is a waste of time and money, and ultimately worthless, or worse yet a liability, from a legal perspective. In contrast, a quality program, fully and continuously documented, could be spotted just as fast by OSHA inspectors.

An RF Radiation Safety Program, regardless of the specific operating environment it is designed to serve, has several basic elements:

- An initial survey of the heat sealer and its operating environment
- Written documentation of the program
- Employee training
- Adoption of administrative and engineering controls
- Someone who is responsible for administration and enforcement of the program

#### **Initial survey**

When creating an RF Safety Program, assume nothing when conducting an initial survey. Make measurements to determine areas that exceed, or could exceed maximum permissible exposure levels (MPE). If needed, these services are available from consulting engineering organizations.\*

Once the baseline study is complete, the next steps can be accurately assessed. These steps may include modification or even replacement of RF heat sealers, depending on their age and likelihood of creating an acute overexposure situation.

#### **Adoption of administrative and engineering controls**

These two types of controls are very different in their scope and end result. An administrative control is an action, such as placement of signs in areas where high levels of radiation are present or writing a policy covering RF equipment, that are not generally implemented in hardware. Engineering controls include fences, barriers, gates, locks and other physical impediments to human presence that are implemented with some type of hardware solution. Sensors that automatically shut off the heat sealer should the shields fail are a pure engineering control that is highly regarded by regulatory agencies such as OSHA.

## Written documentation of the program

Creation and publication of the RF Radiation Safety Program is an essential element and not simply an administrative detail. This document clearly states the program's goal, its procedures, and shows how the organization is addressing employee safety. It is as valuable for subjective reasons as it is for simply "getting it all down on paper."

The documentation should clearly describe all procedures, who is responsible for conducting them, when they are to be conducted, who to contact if a problem is detected, and many other areas. A complete guide to establishing an RF Radiation Safety Program is available from Narda Microwave-East.

## Employee training

Every employee whose work is in any way connected with operation, maintenance, or inspection of the RF heat sealer must be trained, thoroughly, about the program.

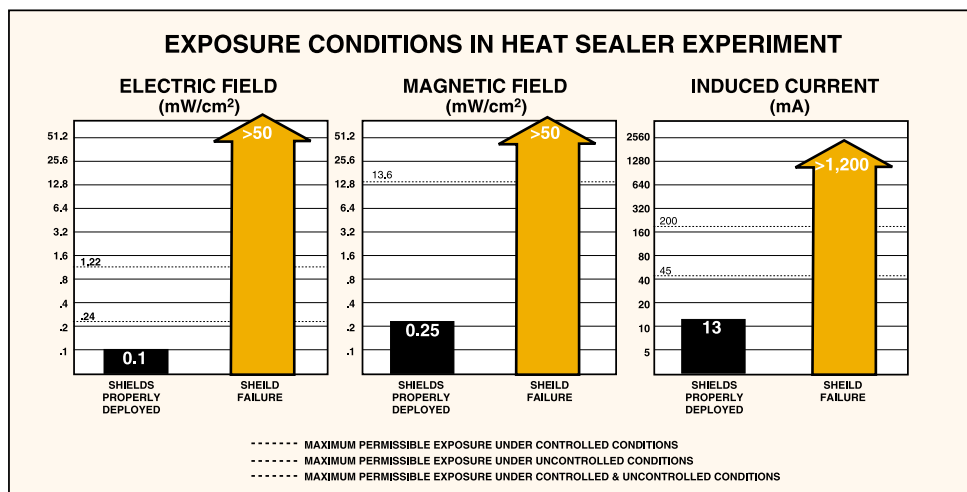
All new employees who meet these work criteria should also be trained as part of the initial indoctrination. If changes are made to the program, they must be communicated, in text form and verbally, to the employees. Periodic review of the program must be conducted by the program administrator.

## Assignment of someone to administer the program

Administration of an RF Radiation Safety Program does not require large amounts of time or money. However, the person in charge must report on a regular basis the status of the program, and the program itself must be continually documented.

## ENSURING COMPLIANCE WITH RF RADIATION MONITORING

One of the most fundamental elements of ensuring compliance is monitoring, with precision instruments, RF radiation in the critical areas around the heat sealer.



## THE IMPACT OF SHIELD FAILURE

An experiment was conducted using a modern 12 kW (12,000 W) RF heat sealer operating at a reduced power output of 8 kW. Since the RF power output of heat sealers typically ranges from 1.5 kW to more than 60 kW, this is an average condition. Obviously, the impact of shield failure is less significant with smaller sealers than with those that have higher output powers.

In this experiment, measurements were made at the normal position of the operator with the shields functioning as designed, and with the shields opened only 1 in. above the "safe" position on the operating platform. Completing removing the shields would result in far higher levels of radiation. The values obtained are compared in the table to controlled and uncontrolled Maximum Permissible Exposure levels (MPEs) specified in IEEE/ANSI C95.1-1991. The exact intensity of the electric and magnetic fields with shield failure is not known because radiation levels exceeded the measurement limits of the instrument.

The new standard allows the value of electric and magnetic field levels to be reduced by multiplying the obtained value by the duty cycle of the equipment (typically 10 to 50 percent). However, the new standard limits the value for induced current to a 1 second maximum exposure. Consequently, induced current is now the critical requirement to meet in order to be compliant.

In general, the results show that with shields operating as designed, radiation is well controlled and within the limits set by the standard. However, with shield failure, radiation levels exceeded by more than 40 times the maximum levels considered acceptable, and they were only moved 1 in. from the "safe" position.

## Application Notes

The equipment discussed here is manufactured by Narda Microwave-East, and is designed to serve different needs. The products are designed to:

- Continuously monitor and protect the heat sealer operator,
- Provide protection for maintenance personal
- Make compliance measurements

### Personal Protection

The Nardalert personal monitor is excellent tool for people who must perform maintenance on any part of the heat sealer, not only in the press area but around the generator as well. It is about the size of a pack of cigarettes and fits in a jacket or shirt pocket. Nardalert provides wearable protection against overexposure to nonionizing radiation in models that cover 100 kHz to 100 GHz, which covers all RF heat sealers. Nardalert has visual and audible alarms and operates on batteries for up to 750 hours.

### Compliance measurements

The Model 8513 industrial compliance meter is designed for use by industrial plant managers and safety professionals who must prove compliance on a routine basis. It is ideal for quickly checking the shields and cabinet doors for leaks whenever they have been adjusted or opened.

It is also the only instrument that can measure both magnetic (H) and electric (E) fields with one probe that is permanently attached to the meter, eliminating the need to change probes with each type of measurement.

*\*For help in selecting a consulting engineer, contact Narda Microwave-East, (631) 231-1700.*

### PUTTING THE HEAT ON SEALERS

The new IEEE standard, entitled *The IEEE Standard for Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*, was first published in the spring of 1992. It was adopted by ANSI without change a year later. It is also quickly becoming the de facto US standard for radiation from RF fields. The US Department of Defense has based its new standard on the new IEEE/ANSI standard. The Federal Communication Commission's 1997 Regulations are based on a similar but somewhat more restrictive standard. OSHA is beginning to use it as the basis for enforcement as well.

#### The Standard

The new IEEE/ANSI standard is far more complicated than its predecessor and differs in several important ways that will impact manufacturers of RF heat sealers:

- Radiation levels are no longer advisory, but are now stated in terms of Maximum Permitted Exposure (MPE) levels.
- The two tiers of exposure limits—controlled and uncontrolled—are now used. The uncontrolled limits are typically 20 percent of the controlled levels.
- Induced and contact current are now included. In general, RF heat sealers with E-field radiation levels that hover around the MPE will exceed the induced current MPE value. RF heat sealer operators have always been able to apply the sealer's duty cycle (typically 10 to 50 percent) to reduce electric field level. Induced current has a 1 second maximum, not a 6 min. average, like previous standards. This significantly increases the difficulty of compliance, especially for heat sealers.
- Magnetic field limits have now been relaxed below 100 MHz.

#### OSHA

OSHA has already cited and fined organizations for exceeding the new standard, even though OSHA's official stance remains unchanged since 1978. OSHA has the right to enforce based on a consensus of scientifically-based standards under its general duty clause. OSHA's interpretation of the implications of controlled and controlled environments are defined in that agency's reply comment to the FCC.

Factoring in the loss of duty cycle averaging, one NIOSH official has stated that even at the controlled levels the new standard is about 10 times more restrictive for heat sealers than its predecessor. Without an RF safety Plan, OSHA appears more than willing to enforce uncontrolled levels that are five times more restrictive than the controlled levels. The development of a meaningful RF safety plan appears to be the first step for heat sealer operators.

