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OCCUPATIONAL MEDICINE IN THE ELECTRONIC AND ELECTRICAL INDUSTRY

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Probably no other industry has developed so rapidly, made greater inroads into the intricacies of science, or taxed the imagination and ingenuity of man more than the electronics industry. From the simple, humble beginnings of the crystal set radio and vacuum tube to the complicated marvels of TV microwave devices, computers, lasers, etc., electronic engineers continue to push back the barriers of the seemingly impossible to accomplish the incredible.

However, in the course of such achievements numerous safety hazards, toxicological problems and industrial hygiene difficulties have been encountered. Naturally, in any electronic operation one has to deal with a variety of solvents, gases, plating chemicals, caustics, acids, fire and explosive hazards, industrial and diagnostic x-ray, noise, toxic plant effluents, etc. I shall treat hurriedly of these common universal hazards in order to provide time for the more exotic issues in the electronics industry.

The common chemical hazards include mercury, lead, arsenic, cyanides (plating), hydrogen sulfide, molybdenum, germanium, trichloroethylene, beryllium, magnesium, phosphine (deborane), methylene chloride, photo resist (mixture of polyvinyl, alcohol, ethyl alcohol and ammonium dichromate), caustic, hydrofluoric and other acids, sulfur dioxide, ammonia, amyl acetate, amines, vanadium, yttrium, europium, barium, strontium, calcium, cadmium, zinc, manganese, nickel, the epoxy resins, polyurethane resins, radioactive materials, and phosphors.

Phosphors

With the exception of the phosphors, you undoubtedly have had experience with all of the aforementioned chemicals, both as to their degree of hazard and the safeguards necessary to control these hazards. However, to some the word phosphor may be a relatively new term, as it is primarily confined to fluorescent tube and TV tube manufacture, both monochrome and color. By definition, a phosphor is a combination of chemicals

blended together to produce a new chemical structure with characteristics different from its constituents and capable of luminescence.

In the early development of luminescent phosphor chemicals, you may remember beryllium and the resultant toxicological hazards it presented before eventually being brought under control. Hard on the heels of the fluorescent lamp came a new electronic device: the television receiver. Furthermore, the development of color TV in 1954 entailed the use of new and exotic phosphors not previously employed. Looking back upon the history of beryllium phosphors, one may anticipate that new industrial hygienic problems will come with the new phosphors. Regrettably, as in the early days of beryllium use, no toxicological information of sufficient scope is available to give one a background in the approach to management of the clinical problems of workers who are exposed to these new materials in their occupations. The physician in industry, therefore, must devise an approach to determine the level of toxicity and the extent of a medical engineering control program to protect employees as well as any potential product liability. Let me outline briefly how occupational medicine might attack such a problem.

Two main issues present themselves:

1. That of exposure to the raw materials used to make the powder or phosphor covering the face of the TV tube — in this instance europium-activated yttrium orthovanadate, used to produce a superior color and brightness as compared to the older and relatively less toxic silver-activated zinc cadmium sulfide.
2. That of exposure to the finished phosphor after it has been fired and a new chemical structure formed — new in crystalline structure, solubility particle size, and new in its toxicological properties.

As the name implies, this new solid state compound europium-activated yttrium orthovanadate consists of a mixture of the metallic

element vanadium as an orthovanadate combined with yttrium, all activated in the presence of specific quantity of the rare earth europium. The three components of this new luminescent phosphor all contain their own individual toxicology, with vanadium being the only one of which we have some depth of knowledge. The literature and scientific experience is conspicuously devoid of data regarding the rare earths yttrium and europium. However, particularly in the electronics industry, the rare earths are being utilized to an ever increasing degree in the production of new types of alloys, microwave devices, lasers, masers, insulators, capacitors, semiconductors, ferroelectrics, and probably most of all in the manufacture of powders or phosphors for color TV screens in order to produce more vivid color reproduction.

Pharmacology and toxicology reveal that the rare earths possess a relatively low level of toxicity. Vanadium and its compounds, on the other hand, are known to be definitely toxic. Therefore, we must gear our controls to the most toxic element of the phosphor; namely vanadium.

The human response to vanadium has been well documented. The symptoms are usually as follows: conjunctivitis; irritated nasal passages with mucous discharge; irritation of respiratory tract with bronchitis and bronchospasm; chest pain with pneumonitis, dyspnea, and paroxysmal cough; weakness persisting after exposure; and, occasionally, palpitation. A greenish black discoloration of the tongue is frequently present, as is a contact-type dermatitis with associated hypersensitivity. Allergy is a factor, as some people may react positively to patch tests with a sodium vanadate solution.

Because of these facts and because so little else is known particularly in reference to the finished TV phosphor and its application, the medical department decided upon the following medical control program:

1. Initial selection of workers is made to exclude from exposure any new employees having any chronic disease of the lungs or respiratory tract such as chronic bronchitis, pulmonary emphysema, nasal or sinus infections, conjunctivitis, allergic disease of the skin, or other allergies.
2. Complete pre-employment physical examination repeated annually.

3. Chest x-ray (14x17 PA) repeated annually.
4. Vital capacity — repeat every six months.
5. Body weight and blood pressure — repeat every six months.
6. Complete blood count at pre-employment — repeat annually.
7. Thymol turbidity annually.
8. Urinalysis annually — urine albumin every six months.
9. Urinary vanadium levels repeated annually or at any time signs of vanadium intoxication may appear.

As a result of this type of medical program in effect for the past five years we can now report that:

1. Exposure of a plant population (3,000 employees) has resulted in an incidence of 30 per cent annual rate of minimal injury by vanadium — all reversible.
2. No chronic or systemic disease effects were found.
3. No significant x-ray changes were observed over a five year period. No blood dyscrasias or elevation of blood pressure or changes in pulmonary function.
4. The incorporation of vanadium as the orthovanadate into the crystalline lattice of the phosphor apparently results in the formation of a compound of much lower toxicity than that of vanadium pentoxide alone.
5. Operations were begun in 1963 and to date the population at risk averages 3,000 people with 20,000 man hours of exposure. No toxicology of a permanent damaging nature has been observed in any of our exposures during this time.

With the foregoing experience and the fact that we can keep our exposure levels to below 0.5 MG/M₃, the calculated safe level, we now can relax our medical program to some degree. However, in spite of the excellent prophylactic effects of preventing occupational disease from this toxic material, it is necessary that continuing study be exercised to ascertain if delayed effects will occur such as those which occurred with beryllium phosphors.

No discussion of occupational medicine's part in the electronics industry would be complete without considerations of hazard

control in laser production and use; also the use of epoxy resins and, as you will recall, the recent apprehension regarding x-radiation from color TV sets.

Lasers

Laser, or "light amplification by stimulated emission of radiation," is an incredible device developed as recently as 1960. There are many projected and actual applications for lasers. For instance, in the field of communication as a possible technique for range determination of both terrestrial and satellite vehicles. Also as a clinical tool in certain ophthalmic or other biomedical procedures. For the welding of refractory metals, or as a military tool to fit into selective weapons systems as a new weapon or as the ultimate in anti-ICBM weapons.

Prevention is the most important aspect of laser safety. Laser is potentially a serious hazard to the eye. Specific levels for safe viewing have been calculated and may be achieved by a combination of distance or suitably optically-absorbing lenses. Specular reflections of laser beams possess health hazard potentials. Subjective brightness of the lesser spot or lack of immediate sensation is no measure of its physiological hazard. The laser working environment should be considered off limits for all but those trained and associated with the instrument.

Procedures involved in setting up a control program against laser hazards in industry are much the same as for other toxic exposures. Success depends on complete orientation, understanding, and cooperation by all concerned. The essentials are:

1. Responsibility for safety rests with the supervisor, assisted by medical safety and the industrial hygienist.
2. All persons assigned to laser operations to be formally indoctrinated on hazards and controls, especially as they apply to the equipment in use.
3. All such persons to receive a medical evaluation prior to taking up these activities. This will include visual acuity, a complete ophthalmological examination, and whatever other procedures are necessary to elicit evidence of pre-existing disease or conditions which might be aggravated by laser exposure. Persons legally blind in one eye are not suited for assignment. The medical evaluation to be repeated at yearly intervals and

immediately after accidental excessive exposure.

4. Each laser source and its characteristics to be reported to the medical and safety department before activation. As with all significant industrial hazards, the best control is at the source; personal protective devices are to be regarded as "just in case". Some of the principal points include:

- a. Details of output capacity of each device should be attached thereto.
- b. The beam should be controlled so as to eliminate exposure to operators, bystanders, and the public.
- c. Warning signs should be posted for employees and anyone approaching the area.
- d. Direct or reflected viewing of the beam must be eliminated.
- e. Protective laser goggles may be used for specific wave lengths up to their rated power resistance.
- f. Electrical hazards should be eliminated by locked switches, procedures for bleeding off capacitors, etc.
- g. Lasers should never be left unattended when energized.
- h. Light pumps (flash tubes) should be shielded to protect eyes from glare.
- i. Exposure to cryogenic materials (for cooling) may be avoided with gloves and aprons. Eye shields will protect from splashes or explosions of flash tubes.
- j. High voltage supply equipment should be checked against x-ray examination and suitable shielding provided as necessary.

Epoxy Resins

Epoxy resins or thermosetting plastics have considerable application in the electronics industry and do present a problem to industrial medicine. Epoxy resin systems contain two reactive components — the uncured basic resin and a curing agent (also known as a hardener, catalyst, setting agent, or activator). When the two components are mixed together, the resulting cured product is a hard plastic having excellent chemical resistance, hardness, adhesive qualities, electrical properties, and strength. When completely cured or hardened, these materials pose no appreciable toxic hazard.

The uncured resin is usually the condensation product of "Bis Phenol-A" and epichlorohydrin which, at room temperature, can be either in the liquid or solid state. Fillers such as fiberglass, silica flour, asbestos, and diatomaceous earth may be added to the uncured resin. Diluents such as organic solvents may also be added.

Curing agents commonly used include aromatic or aliphatic amines, acid anhydrides, organic acids, polyamides, and organic peroxides. The chemical process of curing can be done at room temperature (cold cure) or at elevated temperatures. The curing time will vary from a few minutes to several hours, depending upon chemicals and temperatures used.

Health Hazards. The principal hazard associated with epoxy resin systems is a skin reaction or dermatitis. Epoxy resin dermatitis is largely due to curing agents and solvents. The condition is simply irritation or allergic reaction of skin rather than a general systemic toxicity. Amine compounds, acid anhydrides, organic acids, and organic peroxides which are used as curing agents are both primary irritants and skin sensitizers. Probably the most troublesome of the chemicals are amine catalysts.

Skin contact with these curing agents is responsible for the majority of dermatitis cases associated with epoxy resin systems. The completely cured epoxy resins are relatively inert and do not constitute a dermatitis exposure. However, dermatitis cases are common among workers machining or cutting resins thought to be cured, but which still contain free catalysts. Amine vapors, which are usually abundantly liberated during hot curing processes, cause irritation of the eyes and mucous membranes. In some individuals, they also can cause a lung reaction resembling asthma. These vapors may cause dermatitis among sensitized workers.

Exposure to dust from fillers such as silica flour, asbestos, and diatomaceous earth may present potential health hazards. Fiberglass, which is used in laminating operations, can cause irritation to the skin, eyes, and mucous membranes. Dust resulting from cutting, grinding, and shaping of completely cured resins is relatively inert. If an excess of curing agent is present in the resin, the cured product may contain unreacted curing agents which present a dermatitis exposure.

Explosion Hazards. Most uncured epoxy resins have flash points above 300°F and do not present a serious fire hazard. Some diluents, curing agents, and solvents used with epoxy resin systems are flammable. The fire and explosion hazards associated with epoxy resin systems are normally considered to be slight.

First Aid. If skin contact with unreacted epoxy resin system components occurs, affected areas should immediately be thoroughly washed with a mild soap and water. If eye contact occurs, wash for at least 15 minutes and refer to a physician.

Preplacement Medical Procedures. Workers with a history of skin diseases, allergies or abnormal pulmonary conditions should not be employed in areas where epoxy resin materials are used.

Health Hazard Control Methods.

1. Good general ventilation is necessary for areas using epoxy resin systems. Local exhaust ventilation may be needed at mixing stations and curing areas, especially if large quantities of materials are involved. Curing ovens should be exhausted to the outside.

2. Adequate wash facilities should be provided in the area where epoxy resin systems are used. An ample supply of mild soap and disposable towels should be provided.

3. If possible, areas using epoxy resin systems should be isolated from other areas of the plant.

4. Good housekeeping is essential. All spills should be cleaned immediately. The use of disposable paper overlap on work areas is desirable. Contaminated paper should be removed and stored in covered metal containers. The scrap should be removed from the plant daily.

5. All gloves or tools contaminated with epoxy resin components should be washed in a suitable solvent such as acetone or alcohol, followed by soap and water.

6. Workers should be thoroughly instructed in proper handling techniques for epoxy resin systems, be acquainted with potential hazards, and have close supervision.

Personal Protection.

1. Rubber or plastic gloves (preferably cotton lined) or disposable surgical gloves and arm protection should be worn where

skin contact is possible. After use and before removal from the hands, the gloves should be washed in solvents (acetone or alcohols), followed by a water rinse. Before re-use, gloves should be inspected for leaks.

2. The use of eye protection, aprons, or uniforms may be indicated if this is a potential splashing hazard.

3. Smoking should be prohibited.

4. If skin contamination cannot be removed with a mild soap and water, small areas of the skin may be washed with acetone or alcohols, followed by washing with mild soap and water. Petroleum solvents should not be used to clean the skin.

5. Barrier type protective creams have been used with success for dermatitis control in many plants. However, they are not intended to be a substitute for protective clothing or good personal hygiene.

X-Radiation

At this point I would like to take you into the controversial field of x-radiation from TV sets. This is a medical engineering problem; one that has occupied the attention of the medical department over the past many years. It is necessary at this time to separate the facts from fiction and the fantastic.

Man pollutes his world gradually, almost imperceptibly, and in many different ways. One of the least obtrusive ways he has yet invented is the introduction of man-made radiation into the environment. Attention was called dramatically to that kind of pollution last year when a major TV producer placed on the market more than 100,000 TV sets suspected of emitting x-rays. It is a fact that color sets require higher voltage than black-and-white and are capable of producing some x-radiation. In the case of the aforementioned sets, the problem had to do with a shunt regulator tube which regulates the high electron voltage to the picture tube. Due to engineering error, this tube was poorly shielded and mounted in a position which permitted x-rays to escape from the set. Further investigation with other manufacturers' sets revealed that different kinds of design or servicing problems could account for defective control of color TV x-radiation.

TV set x-radiation can be thoroughly controlled by proper shielding, set design,

and monitoring levels at time of manufacture. The level of radiation from the vast majority of defective sets as identified by the United States Public Health Service represented no known risk to the health of viewers, though in a few cases there were high levels of excessive radiation—as high as 25 or more times the accepted limits. The main concern was over possible harm to descendants of the viewers, but even that seemed highly improbable. It is the medical department's responsibility, in cooperation with the engineers, to keep radiation from TV sets at the proper level. This level can easily be maintained below 0.5 milliroentgen per hour, the limit accepted by science, government, and industry as prudent in a world where man is adding significantly to the radiation dose bequeathed by nature. TV set producers are now providing consumer and technician-proof sets incapable of producing excessive radiation despite the most flagrant tampering. However, the problems of x-radiation still exist in the manufacturing and testing area, and therefore require constant monitoring, medical engineering supervision, and control. We have demonstrated that a properly constructed color TV set offers no health hazard whatsoever.

The following letter, authorized by a competent medical authority, is for the edification of our customers and available for general public information:

"Color and black-and-white television sets manufactured by Sylvania Electric Products, Inc., G.T.&E., more than satisfy all the safety requirements of the National Council of Radiation Protection Measurements, as well as those of the International Commission on Radiological Protection."

Sylvania subjects its television production lines to exacting scientific tests for emission of x-radiation. In addition, we periodically employ outside scientists to make independent tests of our sets, both in the plant and after they have left the factories. These tests employ stringent government-accepted and industry-accepted methods of measurement. Constantly, our engineers conduct tests for x-radiation on our color television sets in production and as consumer products. All tests showed that in more than nine out of ten instances the Sylvania sets showed no detectable x-radiation whatsoever. The only reading in these tests was the background

level of radiation normally present in the atmosphere. Even in the very few sets where an actual radiation reading was detected, the level of radiation was well within the acceptable levels established by government and quasi-government bodies. In other words, Sylvania television sets are safe. We shall make certain that sets we produce in the future also will be safe.

In conclusion, I trust we have briefly

summarized some of the major medical aspects and safety problems peculiar to the electronics industry. There are others, to be sure, such as control of cadmium, the general overall control of plant effluents, etc., but we must necessarily limit our discussion to the major and newer toxicological problems; establishing the facts, and discarding the fiction, along with the sometimes fantastic misconceptions.

THE ROLE OF THE INDUSTRIAL NURSE IN THE ELECTRONIC AND ELECTRICAL EQUIPMENT INDUSTRY

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To those who represent the electronic and electrical equipment industries and who expect to hear magic words just for them alone, I apologize. I know of none. The problems of industry are people — all people — not so much the exposures, nor the environments, but the people who work in those exposures and environments.

To handle the people we need a good medical program. To handle the medical program we need a good industrial nurse. To have a good industrial nurse we must understand what her role should be. Let us discuss some of the industrial nurse's major functions.

Nursing Care

Care for occupational and non-occupational injuries and illnesses will always be a major function of the industrial nurse. She has a responsibility to initiate prompt and skillful emergency care, consistent with her professional training and knowledge of first aid techniques, until the services of a physician can be obtained. The nurse's interest in and concern for the welfare of the ill or injured combined with prompt attention, good judgment, and sound management can be a step toward prompt and uneventful rehabilitation.

The nature and extent of the nursing care provided for non-occupational injuries and illnesses should be determined by the company physician. Generally accepted practice allows for the simple (palliative) treatment

of minor complaints that are not expected to require the services of a physician. The more serious ills that merit medical attention should be referred to the family physician.

In addition to her technical skills, the nurse should recognize the possibility that each visit to the health service may represent a problem of deeper significance than the symptom for which attention is being sought. The so-called "chronic complainer," the employee who suffers frequent minor injuries, or even the daily visitor to the scale may well be an individual crying for help. Careful listening on the part of the nurse may help to uncover an underlying emotional problem and avoid a major tragedy. For this reason, enlightened management has learned not to discourage non-occupational visits to the medical department, no matter how simple the complaint.

Medical Examinations

Medical examinations are an important component of a sound occupational health program. Their value as an aid in providing criteria for safe job placement, in uncovering early physical and emotional changes, and in detecting the effects of harmful working conditions contributes to the maintenance of a safe, healthy and productive employee population. The plant nurse becomes an active participant in the company examination program as she conducts the health interview and performs the preliminary evaluations