United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S8-87/035 Sept. 1987

EPA

Project Summary

An Environmental Source Book on the Photovoltaics Industry

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The report gives background information on the photovoltaics industry to help the U.S. EPA evaluate premanufacture notice (PMN) and significant new use regulation (SNUR) submittals from the industry. It also gives information for the photovoltaics industry on the Toxic Substances Control Act (TSCA) compliance requirements. This industry uses a large diversity of toxic and hazardous chemicals. Attention is currently focused on such gases as silane, phosphine, arsine, diborane, and hydrogen selenide which may be used in large quantities and for which there is limited industrial experience. Most materials used by the industry are already listed in the TSCA Inventory List. Unlisted compounds are used as feedstocks or are the actual products themselves. Manufacturers using or producing unlisted materials must apply to EPA for a PMN. Some materials (especially those defined to be acutely toxic) contained in the Inventory List may be used in larger quantity or in applications which differ from current industrial use; these are potential candidates for SNUR.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report presents background information on the photovoltaics industry to help the U.S. EPA evaluate future Premanufacture Notice (PMN) submittals and the need for Significant New Use Regulations (SNUR), implemented under authority granted by the Toxic Substances Control Act (TSCA).

In this context, this report:

- Gives an overview of the structure and nature of the past, present, and future photovoltaics industry;
- Describes the steps involved in synthesizing and assembling photovoltaic cells, modules, and arrays;
- Identifies chemicals used in these processes;
- Describes potential chemical and physical hazards to workers in manufacturing facilities;
- Describes potential hazards to public health and the environment from routine and accidental releases from manufacturing facilities;
- Describes occupational and environmental control technology options; and
- Discusses applicability of current rules and regulations promulgated under the authority of the TSCA to potential chemical hazards in photovoltaic cell manufacturing facilities.

Production

In 1982, worldwide production of photovoltaic devices was 8.4 to 9.0 MW_p (the maximum amount of power the devices are capable of producing); of this, 4.9 to 5.5 MW_p was produced by U.S. manufacturers. This contrasts sharply with U.S. module shipments in 1975, estimated at 300 kW_p. Corresponding increases have been realized also in the installed annual production capacity, currently estimated to be 13.1 MW_p.

After a dramatic increase in production from 5.7 to 13.1 MW_p between 1982 and 1983, total U.S. photovoltaic module shipments have declined to 11.7 and 8.6

MW_p in 1984 and 1985, respectively. During the same period, however, worldwide production has steadily increased from 9.3 MW_p in 1982 to 25 MW_p in 1985.

Occupational Health Hazards

A large diversity of chemical and physical agents which can present health hazards to workers may be associated with photovoltaic cell manufacturing processes. In order to provide focus to the identification of these potential hazards, they are broken down into four categories: explosives and flammables, corrosives and oxidizers, poisons, and miscellaneous.

Explosive compounds are those which can undergo and sustain chain reactions during oxidation. Of the various compounds used in photovoltaic cell manufacture, silane and hydrogen present the greatest potential explosive hazards. Flammable materials can be ignited and sustain a flame over a range of conditions (e.g., temperature and pressure). In photovoltaic cell manufacture, materials used in relatively large quantity that present flammability hazards include hydrogen and methane. Of these materials, most interest focuses on the silanes because of the pyrophoric nature of these materials and their relatively large scale applications.

The health effects of poisonous materials may be divided into two classes for discussion purposes: acute poisonings arising from short-term exposures to relatively large concentrations of materials which may cause shock (collapse), severe inflammation of the lungs, or even death; and, a wide range of effects arising from low-level sublethal exposures which may continue over periods of months or years.

In photovoltaic cell manufacture there are a variety of toxic gases, liquids, and solids that can present acute hazards to workers who are accidently exposed to these agents. Attention has focused on toxic gases (e.g., arsine, diborane, hydrogen selenide, and phosphine) because of their potential large scale use in the photovoltaic industry and because of their potential to expose workers in short periods of time to high doses.

In the manufacture of thin-film photovoltaic cells, electrical and electromagnetic fields generated from process equipment may present occupational hazards. Radio-frequency (rf), plasma etching, plasma deposition, and sputtering equipment, if not designed and maintained properly, may emit nonionizing radiation into the occupational workspace. Laser scribing equipment may also present electrical shock and laser beam hazards to employees.

Environmental Releases

The quantity and type of material released to the environment from a manufacturing facility depend on the production and control technology alternatives used. Specific emission standards for the photovoltaics industry have not yet been set. Emission control standards developed for related industries (e.g., the semiconductor industry), however, may provide guidelines for control technology requirements in the photovoltaics industry.

In these manufacturing facilities, a large variety of materials may be used; some may be released as by products of normal or abnormal plant operations. Although manufacturing facilities may produce liquid, solid, and gaseous effluents, only gaseous effluents are likely to present acute hazards to public health. Liquid and solid wastes may also present hazards, but these can only expose the public indirectly (i.e., drinking water and foodchains) and over longer time periods. Exposures via these pathways can also be more easily monitored and controlled. Hence liquid and solid wastes may present chronic, but not acute, risks to public health.

Air Emissions

At present EPA has not established emissions standards for the routine or accidental discharge of atmospheric pollutants from the photovoltaics industry. National Emission Standards for Hazardous Air Pollutants for arsenic and cadmium might provide guidance to regulators of the photovoltaics industry's use of these materials.

Solid Wastes

Solid wastes produced in some manufacturing processes studied are residuals from the deposition process or environmental control systems. Some of these wastes may be classified as hazardous under the Hazardous and Solid Waste Amendment Act of 1984.

Liquid Wastes

Liquid wastes may arise from wet etching operations or from solvents used in cleaning processes. Efforts are now underway to eliminate wet etching operations. Consequently, attention is now focused on the control of leaking solvents from storage tanks (often trichloroethane). In the semiconductor industry, underground storage tanks have leaked cleaning solvents into the groundwater and contaminated public water supply wells in Silicon Valley. This problem appears to be endemic to many semiconductor manufacturing facilities in that region. As a result of these leaks, many lawsuits have been filed against some large semiconductor manufacturers in the industry.

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The complete report, entitled "An Environmental Source Book on the Photovoltaics Industry," (Order No. PB 87-224 358/AS; Cost: $13.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
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