Health and Safety Executive Inspection of U.K. Semiconductor Manufacturers

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Europe plays a major role in the international semiconductor industry, but has conducted few studies of the occupational health of its workers. An exception is in the United Kingdom, where, in two small studies, the Health and Safety Executive (HSE) evaluated some health effects of semiconductor work. Neither of these studies, largely restricted to Scotland, produced definitive results, and both were misused by industry to assert that they demonstrated no adverse health effect on workers. The results of the studies prompted semiconductor industry inspections recently completed by the HSE that included chip manufacturers in Scotland and other U.K. areas. The results of these inspections are disappointing. *Key words*: semiconductor industry; Health and Safety Executive; electronics industry.

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Scotland is a major European center for semiconductor and other computer electronics. Scotland began with a wartime electronics industry in the 1940s that subsequently brought investments by Motorola, IBM, NCR, and Honeywell. Scotland now produces about 30% of Europe's personal computers and 80% of its workstations. It provides almost half of the semiconductors made in the United Kingdom, amounting to 7% of the total European production. There are over 10,000 employees in the semiconductor industry in Scotland, and almost double that number in optoelectronics and communications technologies. The major semiconductor companies are Motorola, Intel, Semefab, National Semiconductor, Cadence Design Systems, IBM, Axeon, Epson, and Nallatech.[1]

National Semiconductor's wafer-manufacturing plant in Greenock, Scotland, started production in 1970 and currently employs about 600 workers. At one time the plant employed more than 2,000 workers. The Greenock plant had been equipped with equipment from the United States and, according to former employees, had frequent incidents of gas and chemical exposures of workers in the cleanroom. Women workers grew increasingly concerned about a number of health effects and initiated lawsuits for compensation for their illnesses and for their loss of work. Many of the women belong to an organization called Phase Two, and their litigation may soon appear in a Scottish court or be settled outside of court. In 1998 about 50 workers filed a class action lawsuit against the plant, demanding compensation for cancer, birth defects in their children, undue miscarriages, and other illnesses. A similar group of workers organized at Motorola's East Kilbride plant near Glasgow.

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HSE REPRODUCTIVE STUDY

In response apparently to pressure from ex-workers, media coverage, and the growing number of litigants, the U.K. government's Health and Safety Executive (HSE) conducted a study of the spontaneous abortion rate of women working at six semiconductor plants in the United Kingdom. It announced the results in 1998 and concluded that there was no convincing evidence that work in the U.K. semiconductor industry shared the U.S. problem with increased abortion rates.[2] This study was heavily criticized on several points, including the small number of workers included in the study and the lack of distinction between people working in the cleanrooms and those performing jobs without chemical exposures.[3] The study was of such small size that no statistically reliable results were presented to support the HSE position that they had demonstrated an absence of risk.

HSE CANCER STUDY

In late 2001 the HSE announced the results of its study of cancer mortality in a small sample of workers at the National Semiconductor (NSUK) plant at Greenock, Scotland. The HSE Cancer Study found that the overall mortality rate from all causes of death was lower among workforce members than it was for Scotland as a whole, though the total incidence of cancer cases was about the same as for Scotland as a whole. However, the HSE identified higher-than-expected incidences of three particular types of cancer among women in the workforce and one type in men.

There were 11 cases of lung cancer in women—two to three times as many as expected. Three cases of stomach cancer occurred in women—four or five times as many as expected. There were 20 cases of breast cancer—five more than would have been expected. Three deaths from brain cancer occurred among men—about four times as many as would be expected. No important excesses of any other types of cancer investigated were identified.[4]

The HSE study used only a very small group of employees, and a substantial fraction of them had little or no exposure to the chemicals of concern. The HSE investigators simply defined all NSUK Greenock employees as subjects, thereby seriously limiting the opportunities to demonstrate increased cancer risks in the workers who were most heavily exposed. The small sample size was of concern to many of us who reviewed the HSE study proposal. Still, the results substantially reinforce the concerns that prompted the investigation and suggest a work-related cause for several kinds of cancer.[5]

It is remarkable that four apparent excesses in cancer were found in a study with a weak study design and a total of only 71 deaths. However, the relative risks are still subject to very wide uncertainty, and the range of effects (including other cancers and other causes of death) may be substantially larger than present data indicate. Cancer is fairly common at three of the sites reported (excepting brain), and important but small increases in less common sites could have been missed simply because the study was too small to detect them. The somewhat reduced total mortality (presumably a healthy-worker effect), with a near-average cancer registration rate, suggests the possibility of some real elevation in the cancer risks over what these specific workers might otherwise have experienced.

HSE INSPECTION OF U.K. SEMICONDUCTOR MANUFACTURERS

When the HSE published the results of its study of cancer at NSUK in Greenock, it announced that it would inspect all U.K. semiconductor plants over the course of the following year. The HSE inspected 25 plants operated by 22 different companies in the United Kingdom in 2002. At first glance, the inspection report appeared to disclose a number of deficiencies in health and safety programs in the industry. Twenty-two percent of the plants failed to meet "minimum legal requirements" for health provision, ventilation, and health surveillance. Only five plants complied with minimum legal requirements for every issue inspected. As a result, the HSE issued 13 improvement notices and one prohibition notice to five of the companies.[6]

Of 14 notices issued against the semiconductor and related companies in the 2002 HSE inspections, 12 were against Scottish companies yet only five of the 22 companies inspected were Scottish. Four of these five Scottish companies shared 12 of the total of 14 notices issued across England, Scotland, and Wales.[6]

HSE inspectors were critical of the standard of occupational health services. Many of the plant physicians and nurses used by the companies were part-time and were employed by outside entities, not by the companies. Most of the doctors were general practitioners, some of whom had never even visited the plants. In the case of arsenic, a carcinogen widely used by British semiconductor companies, HSE found that plant "surface cleanliness, particularly arising from potential exposure to arsenic in cleaning and refurbishment of ion implant sources, needs to be addressed."[6]

Nonetheless, the HSE reported its findings in euphemistic terms intended to show that there are no serious failures to meet U.K. industrial standards. This is easily challenged since the inspection was so limited in scope and depth. The HSE appears not to have had the funds to perform a comprehensive inspection. No occupational hygiene sampling was conducted by the HSE, and no internal company occupational hygiene data were provided to the inspectors. It is not possible to evaluate the semiconductor industry without obtaining worker exposure assessments. By apparently failing to measure the ambient levels of chemical fumes and vapors (including a number of known carcinogens) in the cleanrooms, according to the 2002 Report, the HSE shares with the semiconductor companies what we view as a substandard practice of health and safety inspection and reporting. Few companies will bother to change their internal policies on health and safety given the superficiality of inspection by the agency responsible for enforcing health and safety regulations.

The processes selected by the HSE for particular attention, "were mainly where carcinogens or suspected carcinogens were likely to be used in semiconductor manufacture." The processes selected, however, do not include the application and development of photoresists, a serious omission since assessment of exposures to carcinogens is a major goal of the inspection. The exposure of workers to ionizing and non-ionizing radiation went without inspection or consideration. To make matters worse, the inspectors came to the conclusion that arsenic is the only Class 1 carcinogen handled by the companies, and that there are "no specific minimum legal requirements for surface cleanliness and companies should set in-house standards to be achieved." The worker exposure to arsenic was not ascertained by the HSE since no sampling (air or surface) was performed. No mention is made in the inspection report of any carcinogens other than arsenic, of which there are many in semiconductor cleanrooms. Moreover, the exposures of cleanroom workers to chemical mixtures and reactant products were not assessed or discussed.

Such superficial inspection procedures then allowed the HSE to conclude that there is "no definite proof that working at the plant has caused an increased risk of employees developing cancer." The inspection was an inadequate appraisal of exposures to carcinogens, and can conclude nothing of the sort. Moreover, the inspections add nothing that would allow the HSE to change its interpretation of the HSE Cancer Study results. A problem with occupational cancer in semiconductor workers has been demonstrated and reported by the HSE and the problem cannot be dismissed until a more definitive epidemiologic study has been conducted.

The inspection report contains many statements that demonstrate a lack of understanding of the worker-exposure problems encountered in the semiconductor industry. Ventilation is evaluated by HSE inspectors as if the semiconductor cleanroom were just another manufacturing setting. In a cleanroom, hundreds of air exchanges are taking place each hour. The work environment requires much more expertise than the inspection of conventional ventilation systems. The HSE inspected semiconductor cleanrooms merely for standard violations of "equipment not working to design specification." Yet even at this weak standard of acceptability, "ventilation was found to be a problem at a large number of inspections."

The HSE inspection found that the semiconductor industry in the United Kingdom relies on local general practitioners (GPs) or family practice doctors who seldom, if ever, work in the plants to provide occupational medicine services; these norromally are not accredited specialists in occupational medicine. They conduct pre-employment examinations of unknown completeness, and evaluate workers who are injured or made ill while at work. The details of worker illnesses and injuries are not made public, and the extent to which the physicians communicate with the employers is not known. Nurses who work in the plants are not subject to evaluations of their quality or competence except by the GPs, who are selected by management. Health and safety personnel, when adequately trained and experienced, ought to be part of the preventive health and safety program development of each company. There is little reason to believe, on the evidence available, that this ever occurs in the plants inspected by the HSE. It appears that some companies may thus be able to evade regulation, enforcement, and often any meaningful external occupational health and safety review of their work. The implications of these types of failings are that chronic illnesses in the workers could develop unhnoticed and unrecorded. Such failings can and should be rapidly remedied.

Many of the most serious problems of worker exposure in the semiconductor industry were not addressed at all. The inspection demonstrated little beyond the HSE conclusion that the semiconductor industry is, "comparable with many other manufacturing industries with some very good practice and some areas where improvements could, and sometimes should, be made. Most companies were close to or complied with minimum legal requirements." In an industry that has been demonstrated by the HSE to have an unexplained occupational cancer risk, this is not nearly adequate inspection and reporting. Nonetheless, the HSE inspection of the semiconductor industry's health and safety programs demonstrates that these company programs are in need of significant improvements. The HSE itself has recently acknowledged that in 2001– 2002, of the 40 million working days lost through occupational injury and disease, 33 million were attriirbutable to ill-health problems.[9] This would indicate that U.K. good practice relative to occupational health may well be poor practice.

MISSED OPPORTUNITIES AND FLAWED PAST PRACTICES

Labor inspectors play an important role in protecting workers in any industry. With limited time and resources, and what appears to be a lack of detailed knowledge about occupational health and safety in the semiconductor industry, HSE Inspectors are assigned a difficult task. Moreover, HSE inspectors are seriously underfunded and understaffed, and face further cuts, with a possibility of losing 50 field inspectors in 2003.[7]

There are serious flaws in the process, analysis, and conclusions of the HSE inspection report. It is disappointing that there is little evidence of the HSE effectively enforcing regulations in an industry that appears to have evaded rigorous and comprehensive inspections in the past. Not surprisingly, the semiconductor industry viewed the 2002 HSE inspection report as "a demonstration that overall compliance with health and safety legislation was comparable with many other industries."[8] For an industry that considers itself to be at the leading edge of science and technology, this is not a ringing endorsement of its health and safety programs. The report could also be viewed as a knee-jerk reaction by the HSE to adverse publicity resulting from the HSE Cancer Study. There are few signs at a senior management level that the HSE has learned from its own past failures. Moreover, the HSE does not appear to be adopting better industry-wide strategies.

The HSE expresses "reasonable confidence" in company management in the semiconductor industry. The basis for this opinion remains unsubstantiated in the report. In Scotland, there is a significant disparity between what the semiconductor industry indicated were sound health and safety practices in the 1980s and 1990s and what many former workers remember to be the case. The 2002 HSE inspection report makes no mention of any earlier inspections carried out by the HSE in these plants. Hence we have no baseline data and cannot assess whether the semiconductor industry has improved or worsened its health and safety standards and practices.

The HSE inspection resulted, in part, from pressures exerted by former workers and their representatives. This is a disappointing demonstration of HSE passivity and perhaps reflects the wider malaise within HSE in addressing high-technology industries. Lack of transparency and a failure to address past practices appear to be hallmarks of the HSE. An inspection strategy needs to be developed that includes not just employers and HSE staff, but also employees, trade unions, and groups such as Phase Two.

The selection of locations to be inspected appears to be a relatively random process. A purposive sample drawing on past reports and incident cases in semicon-

ductor plants could well have produced more meaningful results. HSE selection criteria are not available to readers of the report. It would be useful to know who advised on the selection process and what input there was from employees and their representatives.

The report suggests that notices of some or all of the inspections were telegraphed to the companies and hence gave the companies time to prepare for the inspectors. The HSE has often stated that this practice simply means more effective and efficient use of HSE time and resources. Employees often feel that such a practice provides employers with every opportunity to rectify or hide the worst of their deficient occupational health and safety practices. If so, the inspection report may well present not true working conditions in the semiconductor industry, but rather a best practice of the companies inspected.

The methods used by the HSE to select industrial processes to inspect or investigate are not contained in the report. It is not clear whether the HSE looked at teratogens as well as a select group of carcinogens. Since the HSE has not addressed the issue of birth defects in its studies, it may be that it does not consider them to be important health problems. No indication is provided on how the HSE assessed potential health problems resulting from exposures to chemical mixtures. Since there is so little known about some chemicals and possible chemical mixtures, were these potential problems simply omitted or ignored?

The action plan at the end of the document indicates that chemical handling is deficient. It follows that such deficiencies and the need for significant improvements indicate significant past legal and technical failures of occupational hygiene, health and safety management, and health surveillance. These failures lay with the HSE as well as the industry.

The HSE indicates that they used "procedures" to assess occupational health and safety effectiveness that in the context of risk-control indicators were new to the inspectors carrying out the work. Procedures do not assess effectiveness at all. They are all too often paper exercises that do not evaluate practice, and it is possible to hoodwink inspection teams that rely heavily on paper trails. The rating of "best practice" does not fit with the HSE emphasis on procedures. What is best practice based upon and what evidence was used to support it? The HSE report does not provide any of this information, so it is an untested technique in this setting with no evidence base.

The HSE indicates that the semiconductor industry lacks the means to carry out health surveillance properly. If the industry cannot carry out effective health surveillance, how can the industry and the HSE argue that occupational health was satisfactory in the industry? The sections dealing with monitoring appear to indicate both past failures of the industry and past failures of the HSE to properly inspect the industry. The report casts doubt on earlier HSE assessments about occupational hygiene practice being satisfactory. The companies apparently do not and did not have records of chemical exposures because as far as we know no occupational hygiene sampling was conducted or reported. These failings are highly unlikely to have just occurred but rather are more likely to reflect cultural, organizational, and systems failures in the industry.

The HSE readily admits that enforcement in the industry is a "complex" issue. This is used as a justification by the HSE for what often resulted in verbal advice and letters from the HSE to manufacturers on occupational health and safety matters, even when regulations were being violated. The HSE recognized the flawed approach of the inspection, and provides some recognition of the failure of past HSE inspections of the industry. The shortcomings in the HSE appear to be the result of apathy, complacency, underfunding, and an industry fairly secure in the belief that it will not be regularly and rigorously inspected, and even if it will, not much in terms of punitive enforcement will occur.

CONCLUSION

The HSE is creating the illusion that the semiconductor industry in the United Kingdom is being rigorously inspected and regulated, and that it is the subject of extensive research efforts intended to protect the health of its workers. The results of government regulatory and enforcement efforts, and of its occupational health research to date, fall far short of supporting such assertions. The United Kingdom needs to make a greater effort to improve occupational health and safety than it does, and to fund the HSE to properly safeguard workers. The rest of Europe needs to join the United Kingdom in assuring the health and safety of semiconductor workers. Many European countries should join in the effort to protect high-technology electronics workers.

References

1. EE Times Network. <http://www.eetimes.com>.
2. Elliot RC, et al. Spontaneous abortion in the British semiconductor industry: an HSE investigation. Am J Ind Med. 1999; 36,557-72.
3. Fowler B, LaDou J, Osorio AM, Paul M, Swan SH, Teitelbaum DT. Spontaneous abortion in the British semiconductor industry (letter). Am J Ind Med. 1999;36:584-5.
4. HSE. Cancer among current and former workers at National Semiconductor (UK) Ltd, Greenock: Results of an investigation by the Health and Safety Executive, 2001. Health and Safety Executive, UK.
5. Bailar JC, Bobak M, Fowler B, et al. Open letter to the Health and Safety Executive. Int J Occup Environ Health 2000;6:71-2.
6. HSE. Inspections by the Health and Safety Executive in 2002 of manufacturers of semiconductors in Great Britain. Health and Safety Executive, London. <www.hse.gov.uk/fod/eng-util/semicon.pdf>.
7. Cuts play Russian roulette with workers' safety. Prospect (London), 26 June 2003. .
8. Allen B. OH in the chip industry. Occup Health Rev. 2003; March/April.
9. HSE (2003) Strategic thinking—work in progress: <http://www.hse.gov.uk/flist/>.