

# Regulation of Occupational Health and Safety in the Semiconductor Industry:

## Enforcement Problems and Solutions

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Reports of high incidences of occupational illnesses in the semiconductor industry should have triggered global investigations and rigorous inspection of the industry. Yet semiconductor plants remain essentially unregulated. Health and safety standards are inadequate and enforcement is lax. Roles for stakeholders in laying down good practice, monitoring, and regulating are proposed, and obstacles are described. Effective regulation has advantages for the industry as well as workers. Conditions for best practice include education at all levels, protection and support for labor inspectors, government commitment to enforcing laws, recognition of the right of workers to organize, and recognition of their rights. *Key words:* semiconductor industry; microelectronics industry; legislation; labor unions; worker participation.

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The global semiconductor industry presents a wide range of hazards and risks to employees which may also change over time, work activity, and geographic location.<sup>1,2</sup> Commentators have rightly noted occupational health and safety regulatory problems exist in the industry because of “the development of the microelectronics industry in areas of the world that lack sufficient regulation and enforcement of laws to protect workers from occupational hazards and the community from environmental hazards.”<sup>2</sup> Evidence about governmental regulation and enforcement standards and practices from those countries where the semiconductor industry operates is not encouraging.

There have been major enforcement problems in China and problems with application of good health and safety standards to multinational companies.<sup>3</sup> In the Philippines there has been a lack of occupational health and safety enforcement powers and a recognition that “experience with industrialized countries indicates that *voluntary compliance by industry does not*

*work unless there are also regulations with accompanying penalties for non-compliance.*”<sup>4</sup> In Taiwan, even those papers that do discuss that country’s semiconductor health and safety provide little or no information about the role of statutory external regulation and enforcement.<sup>5</sup> In Malaysia, evidence is emerging that regulation and enforcement of ergonomics standards for wafer-fabrication workers is failing because of the manifestation of work-related musculoskeletal problems in these workers.<sup>6</sup>

The experience of researchers in Asia who explored the electronics industry in the 1980s was that “managers and the government are often under pressure to minimize costs of production and to maximize profits,”<sup>7</sup> and it would seem that little had changed by 2003.

The industry argues that it is “high tech” and capable of identifying and removing any significant risks from the hazardous materials and processes that it uses. There is much debate about this, and some substantial and growing evidence that the industry has provided clean environments to ensure production of its products but, in occupational health and industrial hygiene terms, potentially hazardous environments for some of its workers across the world have been created and then replicated. Where complex, multiple exposures to chemicals occur, sometimes over years of an employee’s life and often at low levels, the occupational health and safety challenges and related inspection and enforcement needs may be great.

Surprisingly, industry guides did not appear to prioritize engineering and industrial hygiene controls when the industry began, but rather emphasized the value of personal protective equipment (PPE). One guide devotes just one page in its opening chapter to engineering controls and eight pages to PPE.<sup>8</sup> Guides to industrial hygiene in the industry were often relatively sophisticated but also primarily based on monitoring of the larger “merchant” semiconductor manufacturers in 1995 and may have been unrepresentative of what was happening globally in the operations of smaller manufacturers.<sup>9</sup> This indicates additional reasons why comprehensive and detailed inspection and enforcement of controls are so critical to effective health and safety practice in such an industry. Other more powerful drivers than occupational health, safety, and the environment (OHSE) seem to have dominated the industry

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agenda. However, unlike detailed analyses of environmental pollution and related regulatory issues relating to high-tech industries in such countries as Japan,<sup>10</sup> little detailed work exists on occupational health and safety regulation and enforcement specifically.

## REGULATORY THEORY: WHY REGULATE?

Some economists, politicians, and health and safety researchers advocate the free play of market forces linked to current ideas about the neoliberal position on regulation first presented by the Scottish economist, Adam Smith. Adam Smith's model is based on the belief that hazardous industries will pay employees high wages because they do dangerous work until a point is reached where it becomes more economical for such employers to remove or reduce hazards and so lower wages. The theory presupposes that workers can choose where they work and also have accurate information about which are the hazardous industries and which are the hazardous jobs. No external regulation and enforcement at all is therefore needed according to this theory.

This has simply not worked. First, it manifestly does not initially remove hazards, so accidents and illnesses will always occur. Second, hazardous industries paradoxically may employ workers, often the most vulnerable groups of workers, at lower-than-average wages precisely because people with a choice of employment do not wish to work in hazardous industries and may be able to choose not to. Migrant workers, illegal immigrants, and the unskilled often have no choice but to work in dirty and dangerous occupations.<sup>11,12</sup> The failure of market forces to protect workers' occupational health and safety has been frequently and well documented.<sup>13</sup> Those who propose OHS management systems that are "self-monitoring, self-correcting and self-improving" recognize the dangers of producing "the trappings of self-regulation without delivering the promised outcomes in terms of improved OHS performance."<sup>14</sup> Much of the history of occupational health and safety in the semiconductor industry may well demonstrate such failings.

With regard to the major players in the IT hardware industry, Geiser and Tickner rightly observed that "global markets mean that the regulatory conditions of the most aggressive nations tend to shape the product design and management conditions for the entire industry." At the same they noted countervailing forces whereby the EU, for example, "can ratchet up its regulatory standards and the industry finds that it must ratchet up its performance even when large shares of its markets are unaffected."<sup>15</sup> What of course we do not know is how raised product standards or harmonized standards impact occupational health and safety standards and practices in the semiconductor industry in those regions where labor is disorganized and little if

any inspection or enforcement of occupational health regulations occurs.

Regulation may run a continuum from regulating every process, system of work, and piece of machinery through identifying key hazards and systems of work that will effectively control ill-health and accidents at work. Regulations may be narrow and prescriptive or broad and generic, linked to risk assessment and risk management. With flexibility may come better health and safety practices, or potentially greater freedom and poorer health and safety practice. There are many different types of regulatory regimens with widely diverse approaches to standard setting and then enforcement of those standards through generic or specialist agencies.<sup>16</sup> Cost-benefit analyses have been playing an increasingly large role in work of regulatory enforcers who are linked to what are called "business-friendly agendas," but could be equally called "worker/community-hostile or apathetic" agendas. It is true that regulations per se cannot address major and international occupational health and safety failings, however well, diligently, and widely enforced such regulations may be.

Four country-specific broad-based occupational health and safety compliance strategies have been identified by Asian researchers: code-based approaches (U.S.); performance-based approaches (U.K.); systems-based approaches (Nordic); and specialist-based approaches (Japan).<sup>17</sup> The U.S. code-based approach was viewed as antagonistic, but if no extensive and effective enforcement occurs, it will not work. The U.K. performance-based approach is meant to draw on unionized labor, usually with employers, to solve health and safety problems. Where unions are absent or weak, however, workers will not be able to press for effective solutions. The Japanese approach was government-initiated, top-down, and depended supposedly on cooperation between unions and employers. It did not work because of inertia. None of these approaches provided effective and rigorous enforcement of regulations in industries such as semiconductors.

What effective enforcement can do is to provide fundamental and basic safeguards and hence one critical element—along with such things as workplace organization and trade union and worker rights, technical resources and skills, employer commitment to worker health, training, information and its dissemination, and media awareness—in the complex picture of good occupational health. Some propose self-regulation or the two-track regulatory approach, which "places primary responsibility on employers and workers themselves to find optimal means of reducing occupational injury and disease subject to government and third party oversight."<sup>18</sup> This harks back to the Robens self-regulation central to U.K. workplace health and safety philosophy, which disingenuously assumed some sort of equality of power between the various players. Self-

regulation by employers and employees always fails employees in workplaces where they have minimal or no organizational power, and would offer little to protect the occupational health of most vulnerable workers in semiconductor plants across the world.

Remarkably, in the occupational health and safety world, against a backdrop of enormous global occupational disease and accident figures, some are working on reducing regulatory interventions even further to protect the most vulnerable workers through addressing “risk aversion.” At its extreme, this is taking the form of educating children in European schools about “risk” in a particular way. Hence, the curriculum may raise the child’s “risk threshold” so that he or she is less “risk-averse” and will, one assumes, accept even lower occupational health and safety standards and enforcement in the workplace.

## REGULATORY PRACTICE IN THE SEMICONDUCTOR INDUSTRY

Striking the balance between effective laws and time-consuming, resource-consuming, poorly targeted and ineffective regulation may be of concern to many working in occupational health and safety. Effective regulation, however, must rest on a clear understanding of the hazards and risks presented to semiconductor workers and recognition that there are significant data gaps and therefore a need to build in, where possible, a precautionary approach. The impacts of market regulations and environmental regulation and enforcement on the semiconductor industry have received attention.<sup>19</sup> Yet very little, for instance, is known about the regulatory enforcement of occupational health and safety standards in the semiconductor industries of Central and Eastern Europe.<sup>20</sup>

The assumption that the semiconductor industry did operate good practice if not best practice and did not harm its workers was challenged in the 1980s and 1990s. Sentinel events, poor health and safety records, and data gaps in the industry’s capacity to assess many health impacts were flagged at this time but not heeded by the industry. By 1991, well-informed commentators with occupational medicine expertise in the field had identified that the incidence of occupational illnesses in the Californian semiconductor industry was unusually high—three times that recorded for general manufacturing industries.<sup>21</sup> These reports should have triggered global investigations and merited rigorous inspection of the industry. Yet what has recently been revealed is that semiconductor plants even in Western Europe and North America remained in several key respects unregulated. Where recent inspections have now occurred they show health and safety standards and practices still leave much to be desired and indicate that effective enforcement of health and safety laws in such plants may be deficient.<sup>22</sup>

High-tech industries may not be the models of good health and safety practice that some thought. For the Silicon Valley Toxics Coalition (SVTC), there was recognition that even the best OSHA chemical-control standards themselves did not provide adequate means to protect worker health and safety in the semiconductor industry even if enforced.<sup>19</sup> Rigorous standard setting for exposures to chemical and physical agents should be the foundation, linked to sound industrial hygiene and engineering controls, for best occupational health, safety, and environmental (OSHE) practice against which regulators assess the industry. However, relatively little research has been carried out on the enforcement of occupational and safety regulations in the U.S. industry. In the United States, however, in 1997 it was noted that no OSHA inspector had been inside the IBM East Fishkill plant for at least ten years.<sup>19</sup> The OSHA Director of Compliance Programs in 1999 stated that “while [OSHA] does monitor [the semiconductor industry] and conducts inspections, the industry doesn’t typically show up on any OSHA programmed inspection targeting system due to its relatively low injury and illness rate.”<sup>23</sup>

In 1989, NIOSH researchers looked at occupational health and safety data they had access to for the semiconductor industries in the United States. They concluded: “more detailed studies to identify processes and/or exposures responsible for illnesses in semiconductor manufacturing are needed. Then it would be possible to develop a control scheme to better protect the worker.”<sup>24</sup> NIOSH also recognized that whereas they had knowledge of many semiconductor health hazards, there were “relatively new types of hazards that have to be dealt with in this industry since process and product technology continue to evolve rapidly” and because “for the ‘new’ potential problems we still know that control and reduction at the source is the primary prevention tool.”<sup>25</sup> Yet inspection and enforcement appear to have played no major part in the development of NIOSH/ OSHA strategies for improving public health in the semiconductor industry at the end of the 1980s. Better surveillance was flagged, more research and control measures were called for, and better dissemination of existing knowledge linked to training was highlighted. Somehow, however, these strands were automatically meant to translate into effective factory action. This was at a time when reports from a number of Californian electronics factories were showing that effective health and safety practices did not apply and many hazards remained uncontrolled and unregulated.<sup>26</sup>

Control schemes to regulate occupational health and their effective enforcement are lacking in many parts of the world at the beginning of the 21st century. Also in the 1980s, other researchers called for a system to be developed in the U.S. semiconductor industry “for ongoing, periodic review and verification of

OSHA-200 and OHS occupational illness and injury classification decisions.”<sup>27</sup> Such a system would again have benefited enforcement agencies, but does not appear to exist.

Enforcement of regulation often relies on indicators of potential problems, because resources and staff of regulators may be limited, and arguments for targeted interventions using such indicators therefore become powerful. There may be additional problems about the state of knowledge in a particular industry or process. For researchers on the health and safety of the electronics industry it was recognized at an early date that “laws are useless if they are not enforced and if the workers are not educated about their rights. Therefore governments should take an active role in continuous monitoring of industry, in education, in providing resources, and in updating and enforcing the law.”<sup>27</sup>

Contradictory arguments exist for rigorous or light-touch regulation or enforcement of occupational health and safety in the semiconductor industry. The dominant industry view is that it has leading-edge technologies and sophisticated control systems, which therefore protect products and workers very well in what is a “clean” industry. The reality has been rather different, and the image of a clean electronics industry was being challenged and documented in the 1970s and 1980s.<sup>26</sup> In California this led to some regulatory activity and enquiry: elsewhere it did not. Internationally, however, the clean image of the industry, and its extensive use of very sophisticated and advanced technologies and materials, appear to have led to many countries’ regulators’ failing either to enforce occupational health and safety standards or doing so in ways that have lacked rigor and proper critical analysis—often relying on industry/company assurances about good practices and hazard controls rather than seeking to validate data themselves.<sup>22</sup>

The other argument recognized that a wide range of known carcinogens, teratogens, other reproductive health hazards, asthmagens, and physically hazardous processes may have been used in the electronics industry.<sup>28</sup> Hence there was a need to carry out careful surveillance. This was because when total cancer morbidity in the electronics industry was compared with that of the general working population in some countries, that morbidity “was significantly higher than expected,” although still modest and often regionally determined. The position was further complicated because health hazards were rarely reported in the 1980s.<sup>28</sup> For the Swedes, such findings, using a Cancer Environment Registry trigger, were sufficient to lead in the early 1980s to calls for more work in the electronics industry, especially to expand use of such registries and to seek specific exposure data. The need for regulation and enforcement in such settings in the 1980s was clear both because of hazard evidence and because large numbers of workers were employed in the semiconductor indus-

try—in the United States alone, there were 279,300 such workers, according to NIOSH estimates.<sup>24</sup>

In 2003, exposure data globally were still very sparse, often not available publicly, or entirely absent.

This was especially the case when there were different industry practices in some companies dealing with the same or similar chemicals: for instance, male skilled print workers—often unionized in the United Kingdom—had pressed for and gained tough regulatory action and substitution policies for glycol ethers in their industries on the basis of international evidence about reproductive health hazards to male workers.<sup>29</sup> Yet regulatory and enforcement action relative to the same group of chemicals in the electronics industry, where unskilled and semi-skilled women workers were employed, appears to have been absent. This may indicate those factors that aid effective enforcement through organized labor. It may also illustrate what Karen Messing has aptly called “one-eyed science” where women are or have been invisible workers, and research on the hazards that may affect them most is neglected. Enforcement strategies and regulatory controls have neglected women workers in the past.<sup>29-31</sup>

Effective or better health and safety enforcement and regulation linked to proper consultation between employers, regulators, and employees appeared to rest on the length of time a trade had existed and the age of the industry, the gender distribution of workers, well established unionization and workplace organization, technical skills, and location of the workers, rather than any activity by labor inspectors. Access to relevant information and its dissemination was also critical to the efforts of the print workers. Women workers in electronics have, however, often moved remarkably fast globally—faster than their male colleagues organized over many decades—and often in far more vulnerable economic and job-security circumstances, to raise and address the health and safety shortcomings of industries and enforcers.<sup>29</sup> These factors and characteristics are important for the introduction, application, and development of good regulatory policies and practices and supporting infrastructures.

## WHO, WHAT, AND HOW TO REGULATE

Effective enforcement should involve inspections of all semiconductor plants at some stage and at some level. Every company would therefore be inspected, and a database about both occupational health and safety problems, technical and organizational, and good practice could be built up and could be accessed by employees, communities, and independent health professionals, provided effective freedom of information provisions were in place. Various production processes would be covered and, again, those in developing countries could check best practice and past best practice elsewhere in the world if they were using materials and

equipment that lagged behind the industry leaders. Enforcement of the law should also relate to owners, directors, and shareholders in terms of corporate accountability, and this would add to the effectiveness of regulatory enforcement, because all industry stakeholders would be held accountable for the actions of their companies in some way.

Resource and staff limits might well lead to necessary targeted interventions, after the initial inspections had established baseline data, in those plants with the poorest health and safety records. Accurate and comprehensive returns about plant occupationally caused and related diseases would be needed to inform such a strategy. Again, it is difficult to see how regulators can use their resources best and intervene effectively if such records are lacking or flawed. The United States's 2002 semiconductor industry baseline occupational health data project, developed for benchmarking purposes, does not serve this purpose because occupational ill health and occupationally caused and related diseases are not properly covered.

### *Market Regulation*

Corporate social responsibility has been the mantra of many organizations, governmental and commercial. But whereas the rhetoric has proved strong, examples of good practice by transnational companies in a global setting are relatively few, and standards have all too often fallen far short of the rhetoric.<sup>32,33</sup>

The U.S. semiconductor industry in the 1990s was subject to voluntary environmental controls as a major control strategy through two initiatives produced by the EPA, one of which was called "the commons sense initiative."<sup>19</sup> Assessments of the effectiveness of such schemes vary considerably. Industry and some government agencies view them favorably; communities and workers far less so. Commentators found neither initiative to be a great success, and their failures do provide some basis for critiquing the use of self-regulation in the work-environment context. Effective legislation setting good standards for protection of health and safety may of course exist yet not be enforced by government agencies. This is far more of a problem than the so-called burdens of legislation.

### *"Technical" Regulation*

Effective enforcement of regulations depends upon a well-trained, well-informed, independent, well-resourced, adequately staffed inspectorate supported by a judicial system that values occupational health and safety at least as highly as profitability and hence enforces the laws rigorously against offenders. Rarely, however, has regulatory enforcement in the industry, be it in Belarus or California, China or Scotland, contained all or most of these elements. Inspectors have usually been understaffed and

under-resourced, often and understandably therefore lacked the time, detailed knowledge, and expertise to inspect such a complex industry.

Evidence from the United Kingdom in 2002 shows that only significant external pressure from former workers and NGOs led to the industry's receiving any systematic governmental inspection at all, and such inspections have revealed major occupational health shortcomings in many semiconductor plants.<sup>22</sup> It also became clear that the enforcement agencies had relied on industry statements about chemical exposures and occupational health records and had not carried out any independent industrial hygiene testing in the plants at all. Former workers from these plants describe health and safety conditions and procedures in the 1980s and 1990s that are very different from those presented by the companies and accepted by the regulatory enforcement agencies. The United Kingdom may be regarded in international terms as one of the better countries for health and safety enforcement. Therefore, the indicators from the 1980s and 1990s in the United States and the 1990s and 2000s in the United Kingdom are that effective enforcement of health and safety laws in the semiconductor industry was at best very limited and often entirely absent. These health and safety enforcement problems extend globally to developing countries.<sup>33</sup>

The limits of regulation and enforcement described above are taken up in the next section, and some solutions to the weaknesses and difficulties identified are proposed.

## **WHO SHOULD REGULATE?**

### *Role for Labor Inspectors; Roles for ILO and WHO in Laying Down Good Practice*

The role of labor inspectors in dealing with such powerful and economically and politically influential industries as semiconductors depends on the existence of an autonomous and adequately staffed and resourced group of occupational health and safety professionals. In the United Kingdom, many viewed the old government factory inspectorate as such a group of effective "labor" inspectors, although in recent years, the capacity of such inspectors to operate in a deregulatory framework must be questioned.<sup>34,35</sup> Danish labor inspectors have led a drive to improve inspection standards, to protect the independence of such inspectors, and to build in principles in their work that place the health and safety employees at the top of their agenda. Unfortunately, anecdotal or legal evidence exists of the subtle and not-so-subtle pressures that may apply to inspectors who carry out or propose rigorous enforcement standards. This has been manifest in Western Europe by anecdotal evidence of the transfers of active inspectors out of geographic sectors or areas of work, by damage to

careers of those who are “overactive” or who speak out, by the deaths of labor inspectors in Brazil, by the hospitalization of French construction inspectors, by the great external pressures placed on inspectors and government researchers in India and Brazil who have been active in addressing asbestos hazards.

### *Trade Union and Worker Safety Representatives and Regulators*

Trade unions may play an important part in monitoring occupational health and safety in workplaces, pressing for higher health and safety standards and helping to ensure effective management of hazards and risks. Workers in trade unions have also filled gaps left by poor regulation. Some workers have documented the existence of “old” occupational disease epidemics caused by conditions that should have been corrected decades ago. They have on occasions shown how very deficient national regulatory enforcement has been by inspecting workplaces themselves and by recording and documenting occupational disease cases in small towns that sometimes exceeded those recorded in national government statistics.<sup>11</sup> By 1984, analysts of the California electronics industry already saw trade unions as a critical influence on the struggle to improve occupational health in the industry.<sup>26</sup> This must surely have been partially due to failures of industry self-regulation and state and federal inspections. Occasionally employers have taken a different tack and, where trade unions do exist, aim to incorporate union members into the management system so they contribute to both in plant regulation and individual employee self-regulation.

Some trade union organizations in the semiconductor industry in 1980s, however, did not identify any role for the effective enforcement of regulations and standards by labor inspectors.<sup>36</sup> Efforts to ensure employees could have input into inspection and enforcement activities in semiconductor plants can be traced back to the early 1980s,<sup>26</sup> but have usually been rebuffed by industry and government agencies in many countries. Where industry/government investigations of the semiconductor industry did occur, these usually shut out worker representatives in the Northern hemisphere and often lacked transparency, making meaningful assessments of their rigor, depth, and validity difficult if not impossible.

Also, in many countries, there will be little trade union activity because of legal, governmental, and employer hostility to worker organizations. Belarus, which has a semiconductor industry, has used the state to try to outlaw and repress trade unions.<sup>20</sup> Semiconductor industries may specifically locate themselves in such countries because, linked to anti-unionism, they will often have low-wage, non-regulated economies with low or no effective occupational health and safety regulatory systems, and grants and tax incentives to attract industries. Transnational industries will look for skilled

workforces, unorganized workforces, and workforces cowed by economic recession. In Western and to some extent Eastern Europe, semiconductor plants have located in exactly such places. Paradoxically, working conditions may be poor because of a surplus of skilled labor and a lack of alternative employment or, as happened in Scotland’s Silicon Glen, wages and conditions in such plants may initially be “above average” and additional payments may be made to workers specifically not to join a trade union.<sup>37</sup> Long run changes in economies occur, however, and wages and conditions may then deteriorate in such plants, where occupational health and safety problems will be neglected and where workforce views on trade union benefits may alter. Many such plants will then de facto be unregulated.

### *Community Regulators and Public Local Authorities*

These do not usually have a direct impact upon working conditions, but they do inform the public, alert workplace regulators, and provide examples of how to reduce or remove industrial pollution problems created by the semiconductor industries.<sup>10,12,38,39</sup> Initiatives in Japan and California from resident groups and NGOs such as the Silicon Valley Toxics Coalition, and others affected by semiconductor industry water pollution, have contributed to increased pressure for effective OHSE enforcement of the industry.<sup>12,39</sup> In less populated regions of the world, where plants either do not present similar water-supply contamination threats, where active NGOs and an alert media are not present, or where middle-class residents have not been affected, pressures for worker health and safety enforcement alone rather than wider environmental enforcement against the industry have been much less.<sup>20</sup>

## **OBSTACLES TO EFFECTIVE REGULATION AND ITS ENFORCEMENT?**

These are many and varied. A number have been identified in previous sections. Such obstacles may link to political, cultural, economic, organizational attitude, structures and approaches in complex and opaque legal systems that all too often favor employers over employees and plants over communities. Possible drivers for complicity in ineffective enforcement linked to inadequate regulation include:

- Nature of organizations—technical and political controls over civil servants and local government officers
- Lack of transparency and limited or no freedom of information rights
- Lack of resources to support staff workloads/needs, fund investigations and possible prosecutions
- Lack of staff—enforcement, technical, scientific, and legal staff—to pursue prosecutions

- Patronage—overt and covert of those who do the bidding of those who control or employ them.
- Political and commercial interference—difficult to assess but indicated by recent research
- Lack of accountability—technocratic decision making divorced from public accountability?
- Legal constraints in drafting of laws and legal constraints in operations of courts.

In the United Kingdom there have been shifts since 1997 in governmental attitudes to regulation that incorporates some of the deregulatory thinking of the previous governments while “accepting that regulation is not only necessary but desirable in certain circumstances.”<sup>40</sup> The DETR consultation document of 1999 on “Revitalising Health and Safety” identified action by health and safety regulators as the last substantive item on a list for action: preceded by actions from employers, designers, and workers.<sup>41</sup> This may reflect the continued dominance of “Robens thinking,” which epitomized a self-regulatory philosophy espoused by Lord Robens, who moved from head of the National Coal Board to Vickers, a major engineering company. The DETR document identified the regulatory tools available, listed in order as awareness-raising campaigns, advice, and response to complaints, investigation, enforcement action, and prosecution. The document specifically noted:

Some people argue that more regulatory effort should be directed at punishment through investigation, enforcement action and prosecution, particularly where lives have been put at risk. These activities use a lot of resources and more effort put towards them would be at the expense of preventative activity. The HSE are conducting several projects to assess the best possible balance between regulatory measures.<sup>41</sup>

This begs questions in the United Kingdom about the inertia generally of the Health and Safety Executive (HSE) and the HSC at a senior level in terms of investigating what regulatory measures work and what do not, what informs the ethical and moral decision-making processes at work in the HSE, and how an organization can conclude that enforcement would be at the cost of prevention. This is so when there has been little if any recent research available from the HSE on the part played by large fines, prosecutions, and imprisonment in deterring dangerous employers and perhaps then preventing some accidents and ill health in the workplace. There is a strange determinism at work here. It may perhaps reflect national political agendas where the key requisite is to be “friendly” to those businesses that year in and year out, decade by decade, have very poor health-and-safety-at-work records affecting both employees and members of the general public. These businesses may also contribute to

the political funds of the major political parties in the United States and the United Kingdom. The DETR observation on penalties that fail to deter people from flouting health and safety law—namely the need for such penalties to be higher—in some respects sits strangely with the view that prosecutions take resources away from preventive action.

Neither the United Kingdom nor the United States is a good model for effective health and safety regulation of semiconductor industry. The United States’s 1980s model of tight supervision to ensure compliance with health and safety laws did not work properly, and OSHA inspectors had many constraints placed on their activity. While the United Kingdom, where “preference for informal persuasion [was elevated] to the status of a fundamental policy principle,”<sup>42</sup> never really got to grips with powerful companies.

Industry too looks at how it may reduce or remove what it perceives as the worst impacts of regulation and enforcement. New EU chemical controls—Registration, Evaluation and Authorization of Chemical Substances (REACH)—present major challenges for the semiconductor industry. The European semiconductor industry association (EECA/ESIA) has attempted to highlight the industry’s health and safety control record. ESIA calls for “legislation proportionate to this minimal exposure risk” and states that the contained industrial systems used in semiconductor manufacture “are almost completely isolated from employees and the environment, thus attaining a minimal to zero exposure risk.”<sup>43</sup> ESIA’s earlier response to draft REACH papers was to raise several concerns.<sup>20</sup> These included emphasizing that their industry was global and so EU controls could affect production in one region when the same process chemicals were used across the world; the industry depended on rapid product development linked to massive investments and so any “slow and cumbersome” chemical vetting procedures would affect profitability and make Europe “highly unattractive to investors”; the industry used large numbers of chemicals with often single source suppliers in a long chain. Such chemicals often had no safer substitute available and controls could threaten European chemical production.<sup>44</sup> These are crude arguments to water down REACH policies but demonstrate how critical in occupational health and safety terms is the need for networks, similar to those of manufacturers, to be forged to protect employee and community health.

## CONCLUSION

Enforcement of sound regulations to protect occupational health in the semiconductor industry is one necessary and essential part of effective industry and company control. Labor inspectors themselves recognize that “good laws are a precondition to effective labor

prevention” and labor inspectors should play “an active and pivotal role’ in inspections.”<sup>45</sup>

Poor occupational health and safety performances and significant occupational disease incidences and prevalences across the globe have demonstrated the necessity for both sound regulation and energetic enforcement. U.K. evidence has raised seriously questions about the value of self-regulation in addressing occupational health and safety problems.<sup>46</sup> Where there has been a complete or major reliance on voluntary action to promote occupational health or self-regulation, there has been failure.<sup>11</sup> In this sense, bad employers themselves have been responsible for the introduction of statutory regulations and encourage enforcement agencies to visit them when they reveal poor industrial hygiene practices, health surveillance, and engineering controls. The semiconductor industry in many countries appears poorly regulated, and those regulations seem to have been poorly enforced if they have been enforced at all.

Proper enforcement of good regulations should of course not mean unnecessary intrusion and unnecessary work for employers. Labor inspectors are also not the only means available to ensure effective enforcement of occupational health standards in the semiconductor industry. Building stronger worker occupational health organization linked to training, information, and protected employment rights may help to ensure good monitoring of standards in workplaces, better recording of industrial hygiene practices, better recording of ill health, and hence better and perhaps more active enforcement action by the regulators.

Countries may have widely different economic, regulatory, technical, political, and cultural profiles. Yet the health and safety challenges often remain remarkably similar. The recent blocking by industry of the publication of a U.S. study about mortality in the semiconductor industry prevented critical health and safety information from reaching workers in that industry across the world.<sup>47</sup> The global moves towards occupational health and safety deregulation and so called “business-friendly” or, more correctly, “employee-hostile” regulation compound the lack of freedom of information to employees about the hazards and risks they still face.<sup>48</sup> Best practice in enforcing good regulatory standards in this industry, to address such problems, therefore usually necessitates:

1. The development of a charter for labor inspectors that offers meaningful protection and support for them in their work, as well as adequate staff and resources, and promotes best practice and autonomy from industry and state influences

2. National governments’ commitment to introducing enforcing good health and safety laws—prescriptive where necessary and risk-based where appropriate—that are properly enforced and linked to meaningful

criminal and civil sanctions for those companies that break the laws

3. Government and industry recognition of the rights of workers to organize generally and specifically with respect to occupational health and safety matters linked to rights to receive information, negotiate with companies, inspect workplaces, and stop work when hazardous conditions are identified

4. An organized, well equipped—in terms of information education, rights—workforce that has clear trade union rights to address workplace health and safety; these will provide another line in enforcing regulation—perhaps through the Swedish worker rights system—not only to inspect workplaces but to stop work in potentially dangerous situations

5. An alert, active, and independent media not cowed or corralled by government and industry

6. Community and environmental groups willing to work with trade unions and employees to press for effective enforcement of work environment as well as wider environmental laws

7. Better educated and informed boards and managers who take the rhetoric of corporate governance and OHSM systems and apply them to raising standards and practices further in their own semiconductor plants

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