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Ethics and Choosing Appropriate Means to an End: Problems with Coal Mine and Nuclear Workplace Safety

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A common problem in ethics is that people often desire an end but fail to take the means necessary to achieve it. Employers and employees may desire the safety *end* mandated by performance standards for pollution control, but they may fail to employ the *means*, specification standards, necessary to achieve this end. This article argues that current (*de jure*) performance standards, for lowering employee exposures to ionizing radiation, fail to promote *de facto* worker welfare, in part because employers and employees do not follow the necessary means (practices known as specification standards) to achieve the end (performance standards) of workplace safety. To support this conclusion, the article argues that (1) safety requires attention to specification, as well as performance, standards; (2) coal-mine specification standards may fail to promote performance standards; (3) nuclear workplace standards may do the same; (4) choosing appropriate means to the end of safety requires attention to the ways uncertainties and variations in exposure may mask violations of standards; and (5) correcting regulatory inattention to differences between *de jure* and *de facto* is necessary for achievement of ethical goals for safety.

KEY WORDS: Administrative actions/law; *de facto*; *de jure*; ethics; health risk law; performance standards; pollution standards; regulation; specification standards; uncertainty; variation; workplace

1. INTRODUCTION

The goal of protecting workers and the public is not always served "by an ever-expanding body of legal regulations enforced by an ever-increasing army of inspectors." Regulations do not promote safety unless those who create risks take major responsibility for safety (Le Guen, 1999, p. 9). Those who create risks and work with them bear primary responsibility because they typically are able to increase or decrease risks and to overemphasize or underemphasize safety. They often are able to choose the *means*, the practices, and habits, which are necessary to secure the *end* of safety. But how does one choose appropriate means to the end of workplace safety? Often people focus on laws and regulations, *de jure* safety, and ignore the means that *de facto* are necessary to achieve safety. Often they have not learned the lesson that criminal-justice experts discovered. Criminologists know that the way to achieve the end of deterrence is not always by means of harsher laws and penalties. The way to "get tough" on crime typically is not always to impose harsher penalties for illegal actions, because when penalties are severe, judges and juries sometimes refuse to impose them, even on people found guilty. But if so, those who argue for imposing more extreme sentences (like the death penalty), as *means* to the end of crime prevention, often act contrary to their own avowed *end*. They often act contrary, in part, because they fail to recognize the difference between *de jure* and *de facto* sentences.

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They erroneously assume that if they pass tougher *de jure* penalties, then in their practices of interpretation, judges and juries will impose tougher *de facto* sentences. Yet this assumption often is false because, all things being equal, sometimes the harshness of the penalty is inversely proportional to the likelihood of its being imposed (Devine *et al.,* 2001). One lesson for criminal justice is that dealing with crime and its sentencing is not merely a matter of *theoretical* assignment of legal penalties but also a matter of practical understanding of the behavior of sentencers. Because criminal penalties are socially constructed in the sentencing situation, legal theorists must take account of the expectations that govern this social construction. Otherwise, *de facto* legal ends will not be realized by *de jure* legal means.

If this article is correct, then similar lessons may hold for workplace risk. *De jure* safety standards, that is, *performance* standards about allowable levels of pollution exposure, as mandated through regulatory law, will not be met unless one takes account of all the *de facto* means to them. That is, one must take account of all the ways people "socially construct" safety in implementing and applying these performance standards. One way people implement and apply performance standards is through *specification* standards. These standards are not actually laws but are interpretations of what is required to meet performance standards. They are typically achieved through actions intended to implement the performance standards in a given situation. If this article is correct, taking account of specification "standards" requires one to understand the expectations, practices, and intentions that govern not only the physical and legal construction of safety, but also its social construction.

This article argues that current (*de jure*) performance standards, for lowering workplace exposures to ionizing radiation, may fail to promote *de facto* employee welfare. To establish this conclusion, the article argues for five related points:

(1) Taking adequate account of the social construction of safety requires one, following the insights of Hollander (1997), to understand the legitimate expectations, the feasible control, and the due care likely to be exercised in the concrete workplace situation.
(2) Many *de jure* safety laws, performance standards, touted as equal or better in level of protection, actually protect less well than other standards because risk creators, assessors, politicians, and regulators ignore the expectations, control, and level of care affecting the *de facto* creation of risk. In part, they ignore flawed specification standards. A case in point is ventilation requirements for coal miners.
(3) According to recent findings by Linkov and Burmistov (2001), current specification standards for workers at U.S. nuclear plants likewise fail to protect them adequately. Their actual exposures to radionuclides are routinely four orders of magnitude higher than those reported on monitoring equipment.
(4) At least part of the reason for the flawed protection of nuclear workers is faulty specification standards. Used to interpret performance standards, these specified practices for monitoring/recording workplace pollution allow parameter uncertainties and population variations to mask actual violations. This failure to achieve the end of safety for nuclear workers similarly arises in part because employers and regulators ignore the distinction between *de jure* safety, mandated by performance standards, and *de facto* safety, achieved in part through practices known as specification standards. They ignore the ways that flawed means, specification standards, reduce *de facto* safety, even when performance standards (typically mandated by *regulatory laws*), that is, *de jure* standards, remain the same.
(5) Correcting current regulatory inattention to differences between *de jure* and *de facto* workplace monitoring requires both that workplace-radiation standards, specification standards or practices, be improved and that government disclose uncertainty-related and variation-related flaws in current standards. Once these disclosures are made, workers' rights to free informed consent can help ensure congruence between performance and specification standards for pollution.

2. HOLLANDER ON SAFETY

To show that current (what I call "*de jure*") performance standards for regulating workplace exposure to ionizing radiation fail to promote (what I call) "*de facto*" employee welfare, it is necessary first to show how and why *de jure* workplace safety does not guarantee *de facto* protection. Workplace safety is not merely a function of health and safety

requirements outlined in regulatory law through *performance* standards (what exposures are allowed or not). Rather, workplace safety is also a function of *specification* standards (what practices or expectations are taken as means to safety-performance ends). Although she does not use the language of "performance standards" and "specification standards," Hollander (1997) shows that, if assessors and politicians focus only on risk regulations (what I call "performance standards") but ignore three main ways that managers/government officials promote or jeopardize employee safety (through what I call flawed or missing "specification standards"), then workplace risks are likely to increase. Illustrating how managers/regulators "socially construct" workplace safety as a result of different expectations, different levels of feasible control, and different levels of due care, Hollander gives three examples of what can jeopardize workplace safety.

Hollander's (1997, p. 108) first example is that of a large industrial saw for building materials. The German manufacturer of the saw, seeing that it was dangerous for workers to stand near the point at which materials automatically were fed into the saw, painted alternating yellow and black stripes on this danger zone and expected workers to understand to stay away from it. The manufacturer meant these stripes to function as a *de jure* warning. Installed in a plant in the United States, however, the workers did not understand the German manufacturers' expectations about the stripe and about their obedience to it. Instead U.S. workers stood near the zone and, *de facto*, had their arms seriously injured by the equipment.

Hollander's (1997, p. 108) second example is that of a large mechanical press whose manufacturer devised interlocks and guards—*de jure* protections—that required the single operator to use both hands to operate it and thus to avoid a situation in which one of his hands became caught in the press. But the purchaser of the press wished to increase profits and speed up production, so *de facto*, he removed the interlocks and guards that permitted only one person to operate the press. When two people began operating the press, after this removal of the manufacturer's safety equipment, one of the men placed his hand in a dangerous area of the press, and it was crushed. The press manufacturer expected the purchaser not to remove the safety equipment and to value his employees' safety more than profits. The purchaser, in turn, expected his employees to accept more hazardous working conditions and, therefore, to exercise greater levels of due care in operating the press under changed conditions. These expectations and exercise of due care were not realized.

Hollander's (1997, pp. 108–109) third example is that of a small Pennsylvania plant full of dangerous presses. Above the workers' time-in clock, the instructions (for how to punch in) were written in Spanish, whereas all the instructions on the equipment, for how to operate it, were written in English, but English not formulated by a native speaker and hence not clear. Although these English warnings were evidence of attempts to promote *de jure* safety, Hollander points out that, *de facto*, the expectation of the plant owner, that the workers could understand the safety directions on the presses, was not met.

As Hollander argues, these three examples illustrate that the *de facto* workplace is an extremely complicated cultural phenomenon in which social-technical behaviors and relationships shape safety and affect lack of congruity in expectations. Given this complexity, Hollander warns that workplace safety is a function not only of regulations about engineering design and statistical analysis—what I call "*de jure* safety"—but also of human expectations, exercising due care and feasible control—what I call "*de facto* safety." But due care and feasible control—part of morally responsible behavior—require foresight. And one must promote foresight through habits, training, education, understanding, and improvements in complex social behaviors. Otherwise, people are likely neither to behave in morally responsible ways nor to choose appropriate means to the end of workplace safety. They may attempt to serve *de jure* safety but, like the saw operators and press owners, fail to realize that they are not serving *de facto* safety.

3. THE CASE OF COAL MINERS: "REFORMS" THAT REDUCE *DE FACTO* SAFETY

Not only do people fail to take account of the more complex requirements for *de facto* safety when they rely merely on engineered or regulated (*de jure*) safety, but also employers often appear to pay mere lip service to *de jure* safety while, at the same time, promoting steps that decrease *de facto* safety. In other words, employers often use the rhetoric of *de jure* safety while they actively take steps to reduce *de facto* safety. They claim their first priority is workplace safety, but they fail to exercise the foresight, due care, and feasible control that Hollander shows are the requirements of both morally responsible behavior and *de facto* safety. Consider several recent proposed "reforms" in coal mine safety.

In many ways, the mining industry has been at the forefront of public health protection. In response to hazardous working conditions, in 1,890 miners founded United Mine Workers of America. In 1910, when the U.S. government created the Bureau of Mines, it became part of the first federal investigation into occupational safety hazards. And the 1969 U.S. Coal Mine Health and Safety Act mandated the first investigation of occupationally induced illness and the first federally mandated health compensation for workers. The goals of these investigations were to reduce coal dust levels in the mines and to begin a medical monitoring program for workers, both programs that have been successful. In the United States between 1969 and 1989, respirable coal dust in the mines was reduced by a factor of six (Weeks, 1997, pp. 80–82).

Recently, however, under pressure from mine operators, the U.S. Mine Safety and Health Administration (MSHA), a government agency, has proposed several changes in mine-ventilation requirements, in specification standards (see Weeks, 1997). None of the changes reduces *de jure* safety, because the mine-ventilation performance standards remain the same. Nevertheless, subsequent paragraphs argue that the proposed changes all reduce *de facto* safety because they do away with reliable specification standards for ventilation (required employer practices or means to achieve given exposure results or to attain performance standards). Instead, the proposed changes mandate merely performance standards or ends (that is, permissible levels of respirable coal dust), regardless of whether one's behavior (as exhibited in specification standards) is actually a means to the desired end. This weakening of specification standards is touted as causing no reduction in mine safety and is part of a more general argument that industry should be left free to choose the means (specification standards) to the end of performance standards (NEI, 2001). The argument that industry should be left free to choose its own specification standards, or means to the end of pollution control, is based on claims that such freedom will reduce industry's pollution control costs, will increase regulatory certainty, and will forge government-industry "partnerships," all without reducing safety (NEI, 2001). Yet the coal-mine changes do in fact reduce safety because they remove the requirement of certain habits, practices, information, and relationships that have been necessary, in the past, to meet the exposure performance standards. The proposed rule for respirable coal mine dust requires (Section 75.370) each operator of an "underground coal mine to develop and follow a ventilation plan that is designed to control methane and respirable dust in the mine." Nevertheless, there is "no requirement that the plans effectiveness be verified" (MSHA, 2003, Section C).

Moreover, if one considers each of the coal-mine proposals in more detail, then the reduction in safety, despite the rhetoric of retaining the same level *de jure* or performance safety, becomes clear. Subsequent paragraphs show, among other things, the proposals for dropping or changing specification standards actually likely weaken the ability to meet performance standards. These proposals call for (1) reducing the MEV or mean entry velocity of fresh air entering a working section; (2) permitting the brattice to be more than 10 feet away from the face of coal; and (3) allowing more than one set of equipment on a single split of air, among other changes (Weeks, 1997, p. 84).

Industry officials tout the MEV Proposal (1) on the grounds that it will result in no loss of workplace safety because the performance standards (respirable coal dust kept below 2 mg/m^3 of air) will remain the same, whereas only the specification standards (lowering the MEV, provided the performance standard is met) will change. They also claim that changing the specification standards will preserve safety while giving mine operators greater freedom (NEI, 2001). In reality, however, the new standards retain the end or goal of safety (low respirable dust levels) but they arguably remove the required means (low MEV) necessary to attain that end or goal. And if so, then the proposals retain the rhetoric of safety, the *de jure* norm of safety, but they lessen the *de facto* ability to meet that safety standard because they take away the means typically able to achieve it. One reason safety will be lowered by the change is that measuring MEV (the specification standard) is easy and gives instantaneous results. But measuring respirable dust (the performance standard or permissible exposure level, PEL) is far more difficult. Getting the PEL requires the mine operator to take five samples, over a two-month period, at the dustiest worksite, and then to average these numbers over a given workshift. Moreover, there is a disincentive for the mine operators to report the correct PEL numbers, because safety violations bring an automatic citation. Besides, each time the air is sampled, the mine operator must charge the batteries of the sampling pump, calibrate the flow rate, weigh the filter before and after sampling, position the sampling unit correctly, monitor the unit during the workshift, and then wait for two weeks (after the samples are turned in) to receive the results. During these two

weeks, the bits on the cutting head are changed, the crew advances further into the seam, ventilation controls are repositioned, water sprays are readjusted, and so on. Because of all these difficulties and complexities (associated with knowing one is meeting the performance standard), the government has required specification standards (Weeks, 1997, p. 84). Hence, for the government to eliminate MEV *specification standards* (practices that are easily and quickly monitored and that give instantaneous results), but to require PEL performance standards (that are measured with difficulty, with a disincentive for accuracy, and with a minimum two-week lag time), is to retain the rhetoric of *de jure* safety but to reduce the practices that promote *de facto* safety.

Proposal (2), achieving mine safety "reform" by changing the specification standards so as to allow the brattice to be more than 10 feet away from the face of coal, also arguably retains the rhetoric of *de jure* safety but reduces *de facto* safety. (The brattice is a floor-to-ceiling curtain at the side of a working face or seam of coal. Its purpose is to provide fresh air to the miner and to keep dust at the floor. Mine operators do not want to move the brattice frequently, as it is labor intensive.) The new proposals eliminate the specification standard (that the brattice be no more than 10 feet from the coal face), provided that the PEL performance standard (respirable coal dust kept below $2\,mg/m^3$) is met (Weeks, 1997, p. 85). Yet, as in the case of Proposal (1), that is, eliminating the MEV specification standard, Proposal (2) also reduces *de facto* safety while keeping the rhetoric of *de jure* safety. It reduces *de facto* safety because the retained PEL performance standard is difficult to measure, for all the reasons already noted, and because mine operators have strong incentives not to measure accurately. Yet the current brattice (specification) standard is very easy to employ (one needs only a 10-foot rod) and gives instantaneous results and therefore the potential for quick correction of problems. Hence Proposals (1) and (2), to discard the specification standards of MEVs and brattices, massively ignore the social/practical construction of safety and therefore seem likely to result in greater mine-safety problems.

Proposal (3) for mine-safety "reform" is similar to the two previous proposals. This proposal permits more than one set of equipment on a single split of air. When fresh air is brought into the mine, it is "split" many times to ventilate different sets of equipment. Each set comprises miners, shuttle cars, and equipment (such as roof-bolting machines). Current specification standards require that two different groups/sets of equipment not be ventilated on the same split of air because the downwind group would receive the dust generated by the first group (MSHA, 2003, Section C). The proposed changes retain the current performance standard (PEL), but they reject the specification standard (no two sets of equipment on the same split (Weeks, 1997, pp. 84–86). Instead, the new proposals allow two sets of equipment to be on the same split, provided that the mine operator does not operate both sets of equipment simultaneously. However, there is a strong incentive to operate both sets of equipment simultaneously, because it is not cost-effective to let a set of expensive equipment sit idle. Moreover, changing two sets of equipment from the same split (to separate splits) is as easy as a flip of a switch. As a result, violations would be virtually impossible to detect. Besides, OSHA (Occupational Safety and Health Administration) mine inspectors are in a given tunnel only about once a year, and operators often know, ahead of time, when they will arrive (Corn, 2002). But if so, then the rhetoric of *de jure* safety (achieved through performance standards) is undercut by the proposed specification standards, because *de facto* mine safety is likely to be reduced if two "sets" are allowed on the same split of air.

As the preceding analysis reveals, all three of the new coal-mine safety proposals, touted as equal or better in level of protection, actually may protect less well because they ignore the *de facto* creation of increased risk because of weakening specification standards (practices). Instead, mine operators focus only on *de jure* or performance regulations, regulations that are likely to be ignored or violated because they are not promoted and supported by reliable practices. As the Mine Safety and Health Administration admitted, "Because technology that continuously monitors respirable dust and displays dust concentrations in real-time is not yet available for use in underground coal mines, the implementation of effective ventilation plans [specification standards] is the only practical means of reasonably ensuring, on a continuous basis, that miners are not overexposed" (MSHA, 2003, Section C). That is, MSHA says that the specification standards are *necessary means* to meeting performance standards. Moreover, in the current regulatory and fiscal climate, such specification standards also are likely to be necessary because in 2002 the Bush Administration is proposing a 6% cut in MSHA, although coal mine fatalities have gone up three years in a row; in March 2002, Senator Rockefeller of West Virginia said these cuts would cause a 25% reduction in the government's mine-safety-inspection

workforce (Corn, 2002). In March 2002, after 13 miners died in Alabama, UMWA said the deaths occurred because MSHA inspectors failed to return, to check on previous violations, and failed to respond to requests to inspect serious hazards (Corn, 2002). Such reductions in funds for mine inspections, together with a 2003 proposed Bush cut of $9 million and 83 positions in the OSHA; a $28.3 million cut in the National Institute for Occupational Safety and Health (NIOSH); and a $8 billion drop in EPA funding (AFL-CIO, 2003), all suggest there is currently less money for mine inspections at the very time more inspections would be needed, in order to ensure compliance with performance standards, given weakened specification standards. If moral responsibility requires foresight in preventing *de facto* violations and if the new proposals seem likely to encourage such violations, especially in the current fiscal climate, then it is arguable that these proposals are ethically questionable.

4. AIR MONITORING AT U.S. NUCLEAR PLANTS

The current situation in U.S. nuclear plants bears many similarities to that in U.S. coal mines. In both cases, workers may not be receiving, *de facto*, the health and safety protection they deserve and believe they are getting. Yet *de jure*, the performance regulations have not been weakened. Like the coal miners faced with weakened specification standards but the same performance standards, nuclear workers have received, *de facto*, weaker protection from workplace pollution, even though the rhetoric of workplace safety insists that employee protection is paramount. Given the flawed industry record keeping that has plagued nuclear workers in the past (see, for example, Shrader-Frechette, 2001, 2002, especially ch. 7), consider next the current situation of employees in U.S. nuclear plants in more detail, so as to see how their regulatory protection compares to that of coal miners.

According to recent findings by Linkov and Burmistov (2001), air monitoring for workers at U.S. nuclear plants fails to protect them adequately. Linkov and Burmistov argue that workers' actual exposures to radionuclides are routinely four orders of magnitude higher than those reported on monitoring equipment. If one examines the Linkov and Burmistov (2001) findings in light of earlier observations about performance and specification standards, it may be possible to discover how and why the exposure readings are flawed. The lapses in nuclear worker safety arguably occurred because flawed specification standards for recording workplace pollution allowed parameter/model *uncertainty* and population *variation* to mask actual regulatory violations, to mask failure to meet performance standards.

5. VARIATION VERSUS UNCERTAINTY

How do flawed specification standards, practices for recording workplace nuclear pollution, allow regulatory violations to go undetected? Why are actual nuclear worker exposures much greater than reported? One answer is that the specification standards, for monitoring workplace radiation, fail to deal adequately with parameter/model uncertainty and with population variation.

Uncertainty arises in risk assessment because of gaps in scientific knowledge either about pollutants and their measurement or about the models that ought to be used to derive exposure estimates. Parameter and model uncertainties are thus parameter and model unknowns; sometimes these uncertainties can be quantified, but other times they cannot, as when they derive from the way scientists frame or interpret the problem at hand (NRC, 1994, pp. 11–12).

Whereas "uncertainty" refers to knowledge gaps in scientific data, models, methods, and theories, variation or "variability" refers not to what is *unknown about risk parameters* and models, but instead to *differences among people*, either in their levels of exposure or in their responses to the same exposure because of different susceptibilities. The differences among people are functions of factors such as age, lifestyle, sex, genetic makeup, and ethnicity (NRC, 1994, pp. 11, 79). Thus, although variability has to do with differences among individuals, and uncertainty has to do with unknowns in models and data, nevertheless the amount of variability is generally itself a parameter that is uncertain, in part because the entire population that is perfectly representative is generally never known (NRC, 1994, p. 239). This point is underscored by comparing the assessments of the variability in breathing rates and the uncertainty in dose conversion factors used in Linkov and Burmistov (2001) with comparable assessments in a recent series of studies conducted by the European Union and the U.S. Nuclear Regulatory Commission (see Goossens & Kelly, 2000; Goossens *et al.*, 2001, pp. 4.2–4.4). The latter are characterized by distributions that are significantly wider than the former. The impact of these differences has not yet been assessed.

As the preceding paragraphs make clear, the concepts of uncertainty and variation can share much of the same terminology (such as "upper confidence limit," and "standard deviation"). However, uncertainty refers to ignorance about scientific models/parameters, whereas variation refers to differences among individuals. Uncertainty forces risk assessors to determine the *likelihood* that risks will be overestimated or underestimated, whereas consideration of variation or variability forces them to cope with the certainty that different individuals will bear risks both above and below any chosen reference point (NRC, 1994, p. 237).

6. VARIATION AND UNCERTAINTY IN NUCLEAR-WORKPLACE MONITORING

How do some current specification standards or practices deal with uncertainty and variation in ways that mask and underestimate violations of the law (performance standards)?

Currently, according to 10 Code of Federal Regulations (CFR) Part 20, "Standards for Protection against Radiation" (CFR, 1977, 1994), general or fixed air surveys (specification standards allowing a single, fixed, air monitor in a work area at a given workplace) may be used to assess an internal radiation dose in order to determine compliance with occupational regulations (performance standards). Companies routinely rely on general or fixed air sampling, alone, to determine workplace compliance with radiation standards. Yet most practices of fixed air sampling can mask significant variability and uncertainty in the estimated concentrations of radionuclides to which nuclear workers are exposed. The high uncertainty and variability of the model parameters contribute to large ranges of predicted radiation doses to workers. To study the utility of air sampling for internal radiation dose reconstruction and compliance, Linkov and Burmistov separated uncertainty (related to the air concentration measurements of radionuclides) from variability (caused by population-specific model parameters such as breathing rate, and dose conversion factors). Using two-dimensional Monte Carlo simulations to separate contributions of uncertainty and variability to the measurements, they derived input probability distributions for air concentrations of radionuclides from empirical air measurements taken by fixed area air samplers. (Much of the beta and gamma activity was from radionuclides such as Cobalt 60 and Cesium 137.) Linkov and Burmistov next used sensitivity analysis to discover that most of the uncertainty in the workers' internal dose estimates was contributed by use of general air surveys. In one area of the plant they investigated, they discovered that air concentrations changed within four orders of magnitude over two months and within three orders of magnitude within a single day. Because of the high daily and hourly variations, no single value for radioactivity—even a mean—can represent the precise concentration that a particular worker is likely to inhale in a given day. Although the central limit theorem states that the uncertainty in the mean is inversely proportional to the number of observations, nevertheless when the quantity varies by orders of magnitude, no such mean is representative (see NRC, 1994, p. 238). In fact, the National Commission on Radiological Protection (NCRP, 1998) admits that general or fixed air samplers can underestimate radionuclide concentrations by up to three orders of magnitude, perhaps in part because they can be located far from where a particularly high-exposure worker is located. Nevertheless, the U.S. Environmental Protection Agency (EPA, 1992) claims that the arithmetic mean is appropriate for estimating individual worker exposure over the long term.

If Linkov and Burmistov (2001) are correct, one ought use neither only such arithmetic means nor only fixed air samplers. Instead, one would need to use personal air sampling, individual bioassays, and regular whole-body counting in order to reduce the uncertainty and variation in determining reconstructed internal dose and regulatory compliance (Linkov & Burmistov, 2001, p. 70). Nuclear workers are not adequately protected, in part because people rely on *de jure* occupational safety standards, performance standards, but they ignore the *de facto* threats that particular practices or interpretations of specification standards impose on reliable implementation and application of performance standards. In the nuclear case, these practices mask violations and underestimate heavy pollution.

7. LESSONS FROM THE COAL-MINE AND NUCLEAR-WORKER CASES

As the analyses of Linkov and Burmistov (2001) reveal, there are at least two *de facto* scientific problems with monitoring worker radiation doses. (1) The EPA allows employers to use practices based on the *arithmetic mean* of measured air concentrations, even though these concentrations may underestimate exposures (and uncertainty) by three orders of magnitude. And (2) the CFR allows use of practices based

on *fixed air samplers* even though these samples may range over four orders of magnitude. Because of this large range of uncertainty, the samples need to be corrected for given individuals. Thus, with respect to protecting nuclear workers from excessive radiation, current practices are inadequate because although the performance standards (allowable concentrations of radionuclides) are strict, the specification standards (practices associated with use of fixed air samplers and arithmetic means of concentrations to determine safety violations) are unreliable. Thus the protective rhetoric of the performance standards is undercut by the uncertainty and variability of the specification standards.

In the nuclear-worker case, as already discussed, the performance and specification standards concerned, respectively, permissible concentrations of radionuclides, and measurement criteria for determining these concentrations. In the coal case, the performance and specification standards concerned, respectively, permissible coal-dust exposure levels, and practical, physical techniques for minimizing those levels. In the nuclear case, although the specification standards mandated use of given *measurement criteria* for violations, in the coal case, the specification standards mandated use of practical, physical techniques for *reducing pollution*. Nevertheless, in both cases, social use or disuse of these criteria and techniques (specification standards) undercut safety. Coal mine safety was undercut by *rejecting* one type of *protective specification standards* (physical techniques for reducing pollution exposure), while nuclear-workplace safety was undercut by *permitting* one type of *unprotective specification standards* (unreliable criteria for measuring pollution levels).

Why do regulators and industries sometimes pursue such flawed practices or specification standards? None of us would search for an electron with a flashlight. We would not use the specification standard of a flashlight in an attempt to meet the performance standard of detecting electrons. But if not, why do we persist in performing analogous actions that are both scientifically and ethically suspect? Why do we propose ignoring coal-mine specification standards, like MEV (mean entry velocity of air), when we claim we want to satisfy performance standards like PEL (permissible exposure levels), even though we know that meeting MEVs is typically necessary to meeting PELs? Why do we use unreliable nuclear-workplace specification standards (based on arithmetic means for a wide exposure range) when we know that they do not yield reliable information about performance standards, permissible dose? Three answers come to mind. One is scientific, one is political, and one is ethical. We consider these answers, in turn, and then suggest what they reveal about needed reforms in workplace safety.

One scientific explanation for the unprotective and unreliable approach to coal-mine and nuclear-workplace safety may be that scientists and managers want the end, regulatory compliance through performance standards, but they do not want the means (specification standards). They may reject the latter because they say they are too restrictive and inflexible or not cost effective in promoting safety (NEI, 2001). Yet in the case of coal-mine safety, as already mentioned, it is not clear there are alternative scientific means to the same end of safety both because there is no requirement for the effectiveness of these alternatives (MSAH, 2003, Section C) and because there is currently no equipment for real-time monitoring/display of respirable dust (MSHA, 2003, Section C). And if not, then monitoring of effective specification standards seems necessary. In the nuclear workplace case, as already mentioned, the existing practices or specification standards are flawed because they typically err by three or four orders of magnitude. Yet those who reject these arguments would need to show that they have available alternatives that actually meet the performance standards, and this arguably has not been done. But if not, then in both the coal and nuclear cases, those who reject my arguments arguably want the end (performance standards) but not the only available means to them. But to claim to want an end, and not to want the means to it, is irrational. If scientific regulators want the end of, and not the means to, workplace safety, then they are irrational. Their desires for reasonable ends (performance standards) need to be congruent with the means (specification standards) for those ends. At present, the two do not seem to be congruent, at least not in the nuclear-worker and coal-worker cases.

One possible political explanation for the flawed approach to coal-mine and nuclear-workplace safety may be that politicians want the rhetoric of safety, but not the reality of safety. They may prefer mere rhetoric because coal-mine or nuclear-workplace safety costs money, and politicians need to keep both their big donors and their ordinary citizens happy. To accomplish this contradictory feat, that is, keeping both groups happy, the politicians need to talk out of both sides of their mouths. To keep the workers and ordinary citizens happy, politicians must claim to support workplace safety, and they must point to strict

workplace-pollution performance standards. But to keep their big-industry donors happy, politicians must emasculate workplace performance standards by (a) promoting flawed specification standards (the nuclear case) or (b) removing reliable specification standards (the coal case). Thus the rhetoric of strict performance standards serves one goal, while the reality of unreliable specification standards serves the opposite goal. The politicians can talk out of both sides of their mouths and, what is more, the case studies suggest they have been able to do so, without getting caught contradicting themselves.

Something like this contradiction may be going on with current cuts in EPA and OSHA enforcement, with retention of performance standards in the face of decreased inspections and increased numbers of workplace deaths (AFL-CIO, 2002; *Mining Week*, 2002). One author claimed that retention of standards, while allowing specification "flexibility" for business and decreasing enforcement dollars, allows such "doublespeak" (Corn, 2002; see IAEA, 2001).

In response to such political allegations, proponents of free-market environmentalism (e.g., Sunstein, 2002, pp. 30, 122) argue that flexible standards in the past have allowed industry to set goals and meet them cost effectively, as in the case of formaldehyde, DES, and uranium tailings. However, even free-market environmentalists do not argue for specification flexibility in areas where performance is hard to measure, as in the case of air pollution (Sunstein, 2002, ch. 7). And if not, then it is not clear that such arguments would count against the criticisms made in this article.

One possible ethical explanation for the unprotective and unreliable approach to coal-mine and nuclear-workplace safety may be that risk assessors and managers are not aware of the disclosure requirements that are necessary to free, informed consent (see Beauchamp & Childress, 1989, pp. 78–106). If managers fully disclosed, to all interested parties, the degree to which specific specification standards (e.g., personal air monitors) were necessary to meeting existing performance standards (e.g., for permissible worker radiation exposure), then workers would use this information to demand more protective specification standards. Workers likely would not consent to being victimized by flawed or unreliable specification standards that jeopardized their health or safety. Flawed worker protection can continue in part because there has not been full disclosure of the ways (specification standards) managers and regulators may fail to serve safety. Because market proponents, following Adam Smith, are advocates of full and free information as essential to efficient worker and market choices, there should be no quarrel with suggestions here for full disclosure to workers. Moreover, although unions and government also have duties to inform workers of flawed practices (specification standards) that do not lead to meeting performance standards, the primary obligation is with the employer to do so because industry is the risk imposer, and the risk imposer must obtain free, informed consent, because efficient operation of markets, on which industry relies, require full disclosure and free informed consent.

If the possible *scientific explanation* of the flawed congruence between performance and specification standards is right, then scientists and managers may not be deliberately sabotaging workplace safety, but merely naive about what can undercut it. If the possible *political explanation* of the flawed congruence between performance and specification standards is right, then some politicians and regulators may be sabotaging workplace safety, perhaps at the behest of powerful vested interests. If the possible *ethical explanation* of the flawed congruence between performance and specification standards is right, then at least in the nuclear and coal cases, ethicists may be remiss in not promoting greater disclosure of the effects of flawed specification standards on performance standards. Regardless of which, if any, of these possible explanations is correct, they suggest (1) that assessors, scientists, ethicists, and managers need to be aware of the ways that they and others choose means that may not lead to the end of workplace safety because of inattention to specification standards. These possible explanations also suggest (2) that ethicists should be more attentive to the ways in which scientists, politicians, assessors, and regulators may be speaking out of both sides of their mouths, appealing to the rhetoric of strict performance standards, while allowing lenient specification standards to undercut them. Finally, these explanations suggest (3) that, regardless of the most desirable way to promote workplace safety and congruence between specification and performance standards, a good place to begin is by disclosing the facts of the reliability or unreliability of various performance standards. Once such facts are made public, workers and citizens can unite to take corrective action, to ensure that *de jure* or regulatory intentions about safety are recognized and reinforced, *de facto*, in the workplace.

8. CONCLUSIONS

If the arguments of this article are correct, then some allegedly safe U.S. workplaces may enjoy merely *de jure* safety, in part because they ignore the *de facto* ways that regulators, workers, and employers interpret performance standards by means of allowed practices known as "specification standards." Tougher workplace performance standards can help to create greater justice and worker safety only if two conditions are met: (1) the stricter standards themselves promote greater justice and safety, and (2) practices or interpretations (specification standards), used as means to the end of stricter performance standards actually work. We already know that (1) and (2) are false in the criminal-justice case. The stricter penalties do not always lead to stricter sentences (Devine *et al.*, 2001). If the arguments in this article are correct, then there may be good reasons to believe that (1) and (2) also are false in the cases of coal-mine workers and nuclear workers. Thus, if the arguments of this article are correct, then one must examine not only employer claims (and performance standards) about safety but also the employer practices (and specification standards) that actually contribute to, or jeopardize, worker safety.

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