

## Nuclear Janitors: Contract Workers at the Fukushima Reactors and Beyond ニュークリア用務員 福島原発他における契約作業員

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The hydrogen explosions at the three Fukushima Daiichi nuclear power plants in March 2011 launched one of the largest disasters in industrial history. A year after the Japanese government declared that the reactors were under control, experts continued to find radioactive leaks. According to TEPCO's latest estimate, cleaning up the mess—removing fuel rods and debris, decommissioning the reactors, and decontaminating some of the surroundings—will take four decades and cost at least \$125 billion.<sup>1</sup> Along the way, thousands of workers will be exposed annually to levels of radiation well in excess of 20 milliSieverts, the internationally recognized maximum limit for normal working conditions.

At one level, of course, working conditions in the three devastated reactors are anything but “normal.” By definition, states of emergency – nuclear or otherwise – entail a suspension of the

ordinary, a breach of normal rules. In the nuclear sector, this eventuality has been codified. Recommendations developed by the International Commission for Radiological Protection (ICRP) allow for higher exposures during post-accident recovery operations.<sup>2</sup> And Chernobyl established a precedent: at least half of the roughly 700,000 “liquidators” who cleaned up after that accident were exposed to 100 milliSieverts of radiation, and many received far higher doses.<sup>3</sup>

Drawing legitimacy from these precedents and the exceptional nature of the emergency, the Japanese government raised exposure limits for workers to 250 milliSieverts immediately after the accidents. Limits for the general public rose from 1 to 20 milliSieverts. Widespread outrage ensued: citizens and experts loudly denounced the fact that infants were being permitted radiation exposures equivalent to the ICRP maximum for industry workers.<sup>4</sup>

Such outrage rapidly drew attention to the dysfunctions that had enabled the reactor accidents. Clearly, the Japanese public

instinctively understood the observation that scholars who study disasters have made time and again: states of emergency may be exceptional, but they also offer windows onto the ordinary functioning – or malfunctioning – of a society and its institutions.<sup>5</sup> This has been widely acknowledged in the case of Fukushima. The 2012 Japanese Diet report on the reactor accidents, for example, locates their roots not in the earthquake and tsunami, but rather in the social, political, and technological relationships that structured the Japan nuclear industry.<sup>6</sup>

What, then, can Fukushima tell us about the relationship between normal and exceptional working conditions in the nuclear sector? This article addresses this question by discussing the relationship between the Fukushima cleanup and ordinary maintenance work in nuclear reactors.

### The Fukushima cleanup

At this writing, TEPCO reports that over 24,000 men have engaged in cleanup and decontamination work.<sup>7</sup> The vast majority of these people sign up out of sheer economic necessity. They are subcontract employees, recruited through nationwide temp agencies, among local residents rendered unemployed by the disaster, and among the thousands of day laborers who eke out an existence in the notorious slums of Japanese cities. As one contract worker observed, *“If [day laborers] refuse, where will they get another job?...I don’t know anyo*

*who is doing this for Japan. Most of them need the money.”*<sup>8</sup>

Over the course of the two years following the accidents, media reports began to focus on the murky hiring practices that recruited workers for the cleanup. The longstanding relationships between *yakuza* (organized crime) groups and the nuclear industry received special attention. Suzuki Tomohiko, a journalist who went undercover as a cleanup worker, reported that TEPCO had explicitly asked a *yakuz* affiliated recruitment company for “men who [were] expendable.”<sup>9</sup> *Yakuza* leaders, in turn, saw the nuclear industry as safer and a more reliable source of revenue than drugs. In the words of one boss interviewed by Suzuki,

Nukes are a cash cow for us. A steady source of income. Once they're up and running, they just keep on giving. We can get by on only the one line of work. Never have to dirty our hands with meth. Because I really hate drugs. I'd rather wear construction boots than get into the pharmacy business. From your perspective in the broader society, nukes come with a whole treasure chest of taboos, but that's exactly what makes them such a horn of plenty for us in the underworld.<sup>10</sup>

In May 2012, the Fukushima prefecture police arrested a *yakuz* boss for dispatching gang members to the cleanup site.<sup>11</sup> According to Suzuki's report, however, the role of *yakuz* in nuclear operations went much deeper than

simple recruitment: they had been present at some plants from their inception, for example by arranging power company payoffs to local fisheries in exchange for their support in reactor siting decisions.<sup>12</sup>

A survey of cleanup workers conducted by TEPCO in late 2012 found that almost half had been hired under circumstances that violated Japanese labor laws.<sup>13</sup> Not all of these recruitments involved organized crime. But the murky hiring practices left workers vulnerable to abuse. Some never received written contracts. Others had their allowances – allocated for living expenses, or for dangerous work – siphoned off by their employers. One of the most common violations involved disguising a worker’s actual employer: a man might be hired by one subcontractor, only to receive his instructions and pay from another.<sup>14</sup>

One effect of such practices was to dilute – or simply eliminate – responsibility for worker safety. Who ensured that workers did not receive excess radiation exposures: the company with which they signed a contract (assuming a contract even exists), or the company that issued their instructions? Who kept track of the total dose accumulated by any given worker? One quarter of the surveyed workers did not receive reports of their radiation exposures from their employers.



In this photo released by Nuclear and Industrial Safety Agency, a TEPCO worker looks at gauges in the control room for Unit 1 and Unit 2 at the tsunami-crippled Fukushima Dai-ichi nuclear power plant on March 23, 2011.

Clearly, then, there was a huge gap between principle and practice. In principle, cleanup workers – regardless of their employer -- were issued with protective clothing and dosimeters. These were checked at the end of each shift. When a temp worker reached his exposure limit (which did go back down to 50 milliSieverts), he was to be assigned to a different post. More commonly, however, temp workers simply lost their jobs when they reached the limit. No surprise, then, that some occasionally chose to leave their dosimeters in a corner in order to prolong their employment. Subcontracting companies, meanwhile, shifted the economic pressures that they experienced onto their employees. In one documented case, a supervisor ordered his team to make lead-lined cases for their radiation detectors, so that these would register lower doses.<sup>15</sup>

The physical environment onsite only aggravated such problems. In the two weeks following the

accidents, some 40% of these cleanup workers did not wear radiation monitors, because most of the 5000 devices that could have been made available were washed away by the tsunami.<sup>16</sup> Two years later, many parts of the reactors remained impenetrable.

The devastation caused by the earthquake, tsunami, and hydrogen explosions continues to make the work environment unpredictable. Considerable engineering effort has gone into designing robots that can operate in highly radioactive environments. So far, however, even the best model can only be used for reconnaissance: if it falls, it needs human help to get up.<sup>17</sup> Even during normal reactor operations, not every circumstance can be predicted and planned to the last detail. The human capacity to improvise remains essential.<sup>18</sup>

It's tempting to dismiss these working conditions as the unfortunate but inevitable fallout of an extraordinary event. In many respects, the working environment at Fukushima Daiichi is indeed unique. But as the small handful of scholars and activists who have studied labor in the nuclear industry have shown, the social and technological relationships that shape that environment have a long history.

### **Ordinary maintenance procedures in Japan's nuclear industry**

Ordinarily, reactors need to be shut down every 12 to 24 months for refueling and maintenance.

These shutdown periods are known as outages. During these times, spent fuel is removed from the core and new fuel is added. Outages also offer crucial opportunities to inspect, clean, and repair valves, pipes, steam generators, electrical systems, control panels, etc.

Radiation affects inert materials as well as biological organisms. The older the reactor, the more corroded and fragile its components, and the more radioactivity they emit. Maintenance thus gets more onerous, time-consuming, costly, and dangerous over time. In addition, reactors go off-line when they are shut down for maintenance. Today, reactor outages cost well over \$1 million a day. There are thus strong incentives to get through maintenance procedures quickly.

The subcontracting system that currently governs clean up at the Fukushima plants was originally conceived in the early 1970s, as a means of managing the labor requirements and radiation exposures imposed by reactor outages.<sup>19</sup> Utilities hire subcontractors, who divide maintenance operations into smaller units, for which they in turn hire other subcontractors, who hire others... and so on, for a total of eight levels of subcontractors. The hierarchy serves to spread radiation exposure over a large number of workers. Operations begin with workers at the bottom of the hierarchy, who are sent to decontaminate work sites in the "hot zone." They scrub instruments, pipes, floors, walls: basically,

any place or piece of equipment that will require repair or intervention. This decontamination work gives the skilled employees who perform the actual equipment maintenance more time to do their jobs.

Since the beginning, the bottom levels of the subcontracting hierarchy have been populated by unskilled, temporary workers. In a brief study published in 1986, Yuki Tanaka reported the early involvement of *yakuza* syndicates in labor recruitment: “In the worst cases, Yakuza members use[d] intimidation to get workers to go to nuclear power plants in order to make up the numbers required during regular inspections.”<sup>20</sup> Whether or not they had been recruited by gangs, those at the bottom of the hierarchy were all “unskilled and comparatively older workers.” Tanaka described this population as follows:

There are ex-miners who lost their jobs at coal mines because of the drastic change in the government energy policy, day laborers from Kamagasaki and Sanya, discriminated against *buraku* people (similar to untouchables), farmers away from their homes during the slack season, and local retired workers.<sup>21</sup>

Then and now, these day laborers served as “radiation fodder.” Subcontractors worked them to the limit of their allowable exposure, then let them go (until the next time). Employees in the upper echelons of the subcontracting hierarchy, by contrast, were generally technicians and

skilled workers whose companies specialized in nuclear power plant maintenance. These were salaried employees, and over the years they built up considerable expertise in reactor maintenance. Yet in some sense they too served as radiation fodder: subcontracting at all levels minimized the exposures of full-time utility workers.



Two workers at the stricken Fukushima nuclear plant have been admitted to hospital from radiation exposure. March 2011.

Efforts to make Japanese subcontractors’ working conditions visible began in the late 1970s, with the publication of two memoirs written by men who had worked at different levels of the system. Both described the onerous physical constraints imposed by working in highly radioactive environments. Both made clear that all too often, workers chose – or were pressured – to remove protective equipment or bypass safety procedures in order to speed up their jobs. As sociologist Paul Jobin recounts in his recent work on Japanese reactor maintenance, efforts to unionize these workers were spearheaded by photographer-activist Higuchi Ken’ichi, whose powerful photos captured the experience of those at the bottom of the hierarchy.<sup>22</sup> Those efforts met

with no success.

Jobin reports that since 1991, Japanese Labor Standards Offices (under the authority of the Ministry of Health and Labor) have granted compensation for radiation-induced cancers or leukemias to no more than 6 workers, or, in posthumous cases, their families (eight others died of acute radiation after the accidents at Tokaimura (1999) and Mihama (2004)). Some of these cases benefited from extensive publicity through court litigation and support from civil society organizations. In other cases, families insisted on keeping their names secret because they “feared opprobrium from the company or the community... it’s not well viewed to be the parent of an ‘irradiated’ [person].”<sup>23</sup>

Although these compensation cases seem to offer hope, their number is tiny compared to the total number of nuclear power plant workers, which topped 80,000 in 2009 according to the figures cited by Jobin. Nearly 90 percent of all labor in Japanese nuclear power plants since the late 1980s has been subcontracted. During any *one* job, subcontracted workers have received two to three times the annual dose absorbed by utility employees.<sup>24</sup> And that’s assuming that dosages were recorded honestly. Mr. Yokota – a decontamination worker who subsequently headed a small radiation protection company that catered to subcontractors, then fell prey to cancer — gave Jobin a step-by-step description of how he had contributed to falsifying records. In

the course of one interview, Mr. Yokota produced the “no anomaly” stamp he’d used to fake medical reports in cases where the annual occupational health visit had revealed abnormal blood results signaling the possible beginning of cancer or leukemia.<sup>25</sup>

### **Logic and extent of using temporary workers for maintenance**

The International Commission for Radiological Protection is an international non-governmental organization that dates back to 1928, when it was founded by physicists and radiologists seeking to define limits for their own occupational exposures<sup>26</sup>. After World War II, the ICRP’s membership grew, its aims broadened, and it began issuing recommendations on permissible radiation doses in all manner of occupations.<sup>27</sup> Other postwar institutions with interests in radiation protection included the International Labor Organization (ILO), the International Atomic Energy Agency (IAEA), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), which was tasked with collating and analyzing all available data on the biological and environmental effects of ionizing radiation. In principle, the division of labor had UNSCEAR collating scientific data, the ICRP articulating the “fundamental philosophy” of radiation protection in the form of quantitative and qualitative recommendations, and the IAEA and the ILO developing “codes of practice.”<sup>28</sup> All these institutions lacked enforcement powers,

however. Only national authorities were empowered to translate recommendations and codes into legal limits and regulatory structures.

In the 1970s, the ICRP enunciated a principle meant to guide work practices in all nuclear facilities: ALARA, the recommendation that at all times doses be kept As Low As Reasonably Achievable. ALARA was conceived as a guideline for policymakers in the face of ongoing scientific controversy. By the 1970s, most international experts subscribed to the linear no-threshold hypothesis, which held that there was no such thing as a “safe” dose of radiation: all exposure had some harmful biological effect. But some still clung to the threshold hypothesis, which held that radiation exposures below a certain level had no discernible effect upon human organisms (and which nuclear operators found much more palatable). In light of mounting evidence, the ICRP adopted the linear no-threshold model as its working hypothesis. But it did not go so far as recommending that all nuclear operations cease.

Instead, the ICRP sought a way to resolve the fundamental tension between the linear no-threshold model and industrial use of nuclear energy. Noting that no industry operated under perfect safety conditions, the ICRP proposed ALARA as a means of keeping the hazards of nuclear work comparable “to those that are accepted in most other industrial or scientific occupations with a high standard of safety.”<sup>29</sup>

Maximum limits ensured that no worker would receive radiation exposures known to have “deterministic effects” (in other words, exposure levels which demonstrably caused immediate health problems). The limits also sought to minimize the “stochastic effects” of low-level exposure (in other words, radiation levels which sometimes, in some people, induced cancers decades after the exposures). Nevertheless, acknowledging that there was no safe threshold, the ICRP stressed that its recommended limits were “boundary conditions for the justification and optimization of procedures *rather than...values that should be used for purposes of planning and design*.”<sup>30</sup> In other words, employers shouldn’t *plan* for workers to absorb maximum permissible doses. The existing limit should be the *outerboundary*, the limit of acceptability.<sup>31</sup> The “as low as” part of the ALARA principle enjoined the industry to keep exposures well under the limit at all times. At the same time, the “reasonably achievable” part of ALARA offered a way to calculate the amount of money spent on radiological protection: the cost of preventing deaths from exposure should compare to that spent per life “saved” in other industries.

In 1990, the ICRP lowered its whole-body occupational limit from 50 milliSieverts to 20 milliSieverts. Previously, the ICRP had considered only fatal cancers and two generations of hereditary effects in its calculation. The new limit took non-fatal cancers into

account.

Remember, though, that the ICRP has never had regulatory power. It can only produce recommendations. Nations set their own limits, which do not necessarily follow current ICRP guidelines. The annual limit for US and Japanese radiation workers under normal conditions, for example, remains at 50 milliSieverts.

Even this higher limit, however, poses organizational challenges for the industry. Reactors are extremely complex installations. Like all industrial operations, they require careful and frequent maintenance. Performing such maintenance for nuclear reactors requires entering highly radioactive environments. Even wearing the most effective possible radiation suit and protection gear, an employee can easily absorb a quarter of his yearly dose in a few minutes of maintenance work. Using temporary workers enables operators to spread radiation exposure over a larger number of people, and thereby comply with regulatory limits on the maximum exposures of individuals. In principle, then, this “management by dose”<sup>32</sup> ensures that no one individual receives more than the mandated annual maximum.

Unsurprisingly, therefore, the use of temporary workers to manage reactor outages is a widespread practice. In the US, workers who dive inside highly radioactive reactor steam generators during maintenance outages are

known as “jumpers,” “glow boys,” or “sponges.” A single intervention can expose them to one-quarter of their yearly allowable dose: after four jobs, they are “cooked out of work” for the year.<sup>33</sup> Some are temporary workers; others are employees of firms that specialize in outage services. Similar approaches guide maintenance throughout the European nuclear industry.<sup>34</sup>

France – which depends on nuclear power for at least three-quarters of its electricity – adopted the Japanese system in the late 1980s. In her vivid account of French “nuclear servitude” (a term used by the industry itself), sociologist Annie Thébaud-Mony found that subcontracted labor accounted for 80 percent of total radiation exposure in French nuclear plants. Invoking the rem (Roentgen equivalent man), an older unit of radiation exposure that still serves in everyday speech, French reactor maintenance workers drily refer to themselves as “rem beasts” or “rem meat.”<sup>35</sup> Many live a nomadic life, moving from reactor to reactor all around the country. They rarely make more than minimum wage, so although they receive (minimal) housing allowances, many prefer to maximize their revenues by living out of their vehicles. For years, their temporary status excluded them from the powerful labor unions to which most French utility workers belong. In the last decade, however, Thébaud-Mony’s research – in conjunction with activism by civil society organizations and greater media attention — has

made the plight of French maintenance workers increasingly visible.<sup>36</sup>

### Consequences

The research and activism conducted by Thébaud-Mony and others highlights several implications of the subcontracting approach to reactor maintenance.

1) **Greater, and unrecorded, exposures.** As we saw for some of the Fukushima cleanup crew, workers sometimes see a short-term financial incentive in abandoning their dosimeters for certain jobs, so that their radiation exposures are not officially recorded.<sup>37</sup> This prolongs their employment, but it also increases their doses.<sup>38</sup> While the practice is currently most prevalent among temporary workers, historically it has not been unique to this population. In the early decades of the French nuclear program, for example, abandoning one's dosimeter could be a sign of dedication and virility.<sup>39</sup>

2) **Illnesses don't become "occupational disease."** Subcontract workers are often dubbed nuclear gypsies (in Japan) or nomads (in France) because they move around from workplace to workplace, living out of trailers. This intense mobility makes it very difficult to maintain accurate annual or lifetime exposure data. Many severe health problems thus never get recorded as "occupational disease." Workers rarely benefit from compensation, because their diseases

cannot be linked to past exposures in ways that are scientifically or legally conclusive.

3) **Collective dose.** Each year, nuclear plants report the sum total of all doses absorbed by all their employees, a figure known as the "collective dose" of a plant. This figure is used as an indicator of the overall working conditions at the plant, and contributes to assessments of its overall safety record. But utilities don't include the exposures of subcontracted workers in their data.<sup>40</sup> That, in turn, means that data for any given nuclear power plant vastly under-reports the *true* collective dose (i.e., the total exposure received by the sum of both utility and subcontract workers).

4) **Greater risk of systemic problems.** Unlike full-time plant employees, even the most skilled contract workers do not have daily experience operating a reactor, or daily contact with its equipment and instrumentation. The low social status of contract workers, furthermore, makes it difficult for them to report irregularities they might notice. This situation has been linked to maintenance failures in both France and Japan.<sup>41</sup>

A major consequence of the subcontractor employment system is thus invisibility – of the subcontracted workers, of their exposures, of the true collective dose generated by nuclear power plants, and of the extent of radioactive contamination. For example, an international epidemiological study on the relation between

low doses of radiation and cancer conducted between 1990 and 2005, which surveyed 400,000 nuclear industry workers in 15 countries, didn't include subcontracted maintenance workers. For France and Japan, which provided two of the largest population samples, this meant the exclusion of the majority of people working in nuclear power plants.<sup>42</sup>

Such systemic invisibility permeates the nuclear industry in both ordinary and extraordinary times, at all levels, and around the world. Uranium mining in Africa provides an illuminating example. During the Cold War, six African countries—South Africa, Namibia, Gabon, Madagascar, Niger, and Congo—together provided between 20 and 50 percent of the capitalist world's uranium. Yet much like the maintenance employees who keep reactors running, the African workers who toiled in these mines have been largely absent from the scientific studies (and historical narratives) of the "nuclear age." Systematic data on radon and occupational illness were rarely produced for African uranium mines; even when they were, these data didn't make it into the large-scale epidemiological studies conducted by international experts starting in the 1950s.<sup>43</sup> This absence has ongoing repercussions for the production of scientific knowledge. In the early 1990s, for example, an international group of experts conducted a massive re-analysis of data from the eleven existing studies of radon and

lung cancer risk, which covered underground miners in Australia, Canada, China, Czechoslovakia, France, Sweden, and the US. African exposures could not be included or re-analyzed, however, because they had never existed *as data* in the first place.<sup>44</sup> For the workers themselves, the absence of data means that it is impossible to gain recognition for occupational illness, let alone remediation or compensation. Today, regional poverty is so extreme in Niger (currently the largest of the African uranium producers) that people refashion radioactive trash barrels into basins for collecting water.

The area around Fukushima Daiichi remains at risk for similar contamination problems. In January 2013, *The Asahi Shimbun* reported that companies contracted to decontaminate communities had violated work rules. Workers were supposed to collect all contaminated debris in bags, breaking down branches and other bulky items as needed. Instead, their supervisors ordered them to dump materials that didn't fit easily into the bags out of sight: down slopes by the side of the road, in deserted patches of woods, or into nearby rivers. Because these zones weren't officially designated "measurement spots" – and because no one expected contract workers to report the dumping – these supervisors assumed that no one would notice. The accidents, however, have greatly heightened public attention to radioactive contamination and to working conditions. People did notice: local

residents and contract workers flooded the Environment Ministry's office in Fukushima Prefecture with complaints about the practice. Overwhelmed by the volume of calls, officials did nothing other than caution the companies to follow the rules. Only after the story broke in the press did the government promise to conduct a full investigation.<sup>45</sup>

In the hyper-polarized public debates about the world's nuclear and climate future, a favorite argument among the supporters of nuclear energy is that coal causes many more deaths than nuclear power. Changing labor patterns, the transnational distribution of flexible work regimes, and the terrible precariousness of workers across the globe certainly do have severe consequences in many industries. The nuclear industry is far from the only one to employ temporary workers for its dirty work, and the health conditions of such workers are invisible in most industries. Industrial systems of all sorts distribute their risks onto the poorest countries and the most vulnerable populations. But such parallels shouldn't allow us to dismiss the social and health consequences of nuclear labor.

Proponents focus on narrow statistics (such as death in the workplace) to claim that the nuclear industry does not carry exceptional risks. A single statistic like this, however, discounts many other measurements and hides complex social and physiological realities. It is important to remember that the invisibility of vulnerable

workers isn't just a problem during disasters. It's a problem at all times, and everywhere. And when no one is counting, there are global consequences.

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#### Notes

<sup>1</sup> This figure represents TEPCO's estimate in November 2012 (as reported in Hasegawa Kyoko, "Fukushima operator warns clean-up 'may cost \$125 bn'," AFP Nov. 7, 2012). Iwata Kazumasa of the Japan Center for Economic Research warned that taking into account various forms of compensation payments, costs could reach \$250 billion (as reported in <http://newsonjapan.com/html/newsdesk/article/89987.php> and elsewhere).

<sup>2</sup> The ICRP sets no dose restrictions for emergency, life-saving operations conducted by "informed volunteers" in cases when the "benefit to others outweighs rescuer's risk", and restrictions of 500-1000 mSv in the case of "other urgent rescue operations." It suggests *total* occupational exposures be limited to 100 milliSieverts for recovery operations. For an overview of these recommendations, see Table 10 (p. 64) in Nuclear Energy Agency, OECD, *Evolution of ICRP Recommendations 1977, 1990 and 2007: Changes in Underlying Science and Protection Policy and their Impact on European and UK Domestic Regulation* (NEA No. 6920, OCED 2011).

<sup>3</sup> Figures for Chernobyl are endlessly controversial: the number of liquidators, their exposures, and the number of deaths and illnesses resulting from the accident have been subject to debate for years. Overview of official figures (i.e., those sanctioned by UN-affiliated institutions), can be found at <http://www.uncsear.org/uncsear/en/chernobyl>

[.html](http://www.uncsear.org/uncsear/en/chernobyl.html) (for UNCSEAR) and [http://www.who.int/ionizing\\_radiation/chernobyl/en/](http://www.who.int/ionizing_radiation/chernobyl/en/) (for the WHO; both accessed 6 December 2012). An alternative analysis, based on some 5000 Slavic-language studies, is presented in A. V. Yablokov et al., *Chernobyl: Consequences of the Catastrophe for People and the Environment* Annals of the New York Academy of Sciences, vol. 1181 (2009).

<sup>4</sup> In August, the government brought limits for the public back down to the pre-accident level of 1 mSv. A few months later, the annual exposure limit for workers followed suit, dropping to its pre-accident limit of 50 mSv. This is the same as the US limit, and more than twice the ICRP-recommended annual limit. The commission is purely advisory; it has no regulatory authority. Nations set their own limits.

<sup>5</sup> Disasters have given rise to scholarship in many different disciplines. For an overview of the origins of disaster expertise in the US, see Scott Gabriel Knowles, *The Disaster Experts: Mastering Risk in Modern America* (Univ. of Pennsylvania Press, 2011). The classic text on the ordinary problems of complex technological systems is Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (Princeton University Press, updated edition 1999). For a case study of social, legal, and scientific responses to a large-scale industrial disaster, see Kim Fortun, *Advocacy after Bhopal: Environmentalism, Disaster, New Global Order* (University of Chicago Press,

2001).

<sup>6</sup> The National Diet of Japan, *The Official Report of Fukushima Nuclear Accident Independent Investigation Commission* (Executive Summary), 2012.

<sup>7</sup> This figure is taken from the monthly report compiled by the Japan Atomic Industrial Forum; the October 2012 report is available at [http://www.jaif.or.jp/english/news\\_images/pdf/ENGNEWS01\\_1352274658P.pdf](http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1352274658P.pdf) (accessed 6 December 2012). Other sources give higher numbers.

<sup>8</sup> Cordula Meyer, "Fukushima Workers Risk Radiation to Feed Families," (<http://www.spiegel.de/international/world/a-visit-to-j-village-fukushima-workers-risk-radiation-to-feed-families-a-786650.html>) Spiegel Online International, Sept. 21, 2011.

<sup>9</sup> Suzuki Tomohiko, *The Yakuza and Nuclear Power: An Undercover Report from Fukushima Daiichi* (Tokyo: Bungeishunju Ltd. 2011), translation excerpt at <http://www.booksfromjapan.jp/publications/item/1176-the-yakuza-and-nuclear-power-an-undercover-report-from-fukushima-daiichi>, accessed 13 December 2011.

<sup>10</sup> Ibid.

<sup>11</sup> Jake Adelstein, "First Arrest Made Linking Yakuza with Fukushima Nuclear Clean-Up

Crews,"

(<http://www.theatlanticwire.com/global/2012/05/first-arrest-made-linking-yakuza-fukushima-nuclear-clean-crews/52649/>) The Atlantic Wire, May 22, 2012.

<sup>12</sup> Ibid.

<sup>13</sup> Tada Toshio, "TEPCO: Half of contract workers at Fukushima work under dodgy conditions," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201212050007>) *The Asahi Shimbun*, Dec. 5, 2012.

<sup>14</sup> Tada Toshio, "8 companies face order to stop illegal labor practice at Fukushima plant," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201212100065>) *The Asahi Shimbun*, Dec. 10, 2012.

<sup>15</sup> "TEPCO subcontractor used lead to fake dosimeter readings at Fukushima plant," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201207210069>) *The Asahi Shimbun*, July 21, 2012.

<sup>16</sup> "40% of Workers Had No Dosimeter at Nuke Plant Soon After Disaster," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201209040060>.) *The Asahi Shimbun*, Sept. 4, 2012.

<sup>17</sup> Kageyama Yuri, "Toshiba shows four-legged robot for nuke disaster," ([http://www.salon.com/2012/11/21/toshiba\\_s](http://www.salon.com/2012/11/21/toshiba_s)

hows\_four\_legged\_robot\_for\_nuke\_disaster/)Associated Press, Nov 21, 2012.

<sup>18</sup> For vivid accounts of the need to improvise during reactor operations, see Constance Perin, *Shouldering Risks: the Culture of Control in the Nuclear Power Industry* (Princeton University Press, 2005) and Pierre Fournier, *Travailler dans le nucléaire: enquête au coeur d'un site à risques* (Armand Colin, 2012).

<sup>19</sup> Paul Jobin, "Dying for TEPCO? Fukushima's Nuclear Contract Workers," (<https://apjff.org/-Paul-Jobin/3523>) *The Asia-Pacific Journal* Vol 9, Issue 18 No 3, May 2, 2011

<sup>20</sup> Yuki Tanaka, "Nuclear Power Plant Gypsies in High-Tech Society," pp. 251-271 in Joe Moore, ed., *The Other Japan: Conflict, Compromise and Resistance since 1945* (M.E. Sharpe for the *Bulletin of Concerned Asian Scholars* 1997).

<sup>21</sup> Ibid.

<sup>22</sup> Higuchi and the workers he followed are featured in the 1995 BBC film "Nuclear Ginza," available for viewing at [http://www.youtube.com/watch?v=W\\_qb0uAc1dg](http://www.youtube.com/watch?v=W_qb0uAc1dg), accessed 13 December 2012.

<sup>23</sup> Paul Jobin, "Fukushima ou la radioprotection, retour sur un terrain interrompu," in A. Thébaud-Mony, P. Jobin, V. Daubas-Letourneux, N. Frigul, eds., *Santé au travail, de quoi parlons-nous* (Paris: La Découverte, 2012), p.

100.

<sup>24</sup> Jobin, *ibid.*, pp. 90-96.

<sup>25</sup> Jobin, *ibid.*, p. 100.

<sup>26</sup> Its name at that time was the International X-ray and Radium Protection Committee.

<sup>27</sup> For an insider history, see Roger Clarke and Jack Valentin, "A History of the International Commission on Radiological Protection." *Health Physics* 88, no. 4 (2005). For an insider history of radiological standards in

the US, see J. Samuel Walker, *Permissible Dose: A History of Radiation Protection in the Twentieth Century* (University of California Press, 2000).

<sup>28</sup> Soraya Boudia, "Global Regulation: Controlling and Accepting Radioactivity Risks," *History and Technology* 23:4 (2007): 389-406; Soraya Boudia, "Sur les dynamiques de constitution des systèmes d'expertise scientifique. La naissance du système d'évaluation et de régulation des risques des rayonnements ionisants," *Genèses* 70 (2008): 26-44.

<sup>29</sup> ICRP, "ICRP Publication 22. Implications of Commission Recommendations that Doses be kept As Low As Readily Achievable. A report of ICRP Committee 4." Pergamon Press for the ICRP, 1973), 3.

<sup>30</sup> B. Lindell, "Basic Concepts and Assumptions behind the new ICRP recommendations," in

IAEA, *Application of the Dose Limitation System* (November 1982): 24-27, 44-46. In the 1980s, *Radiation Protection: Practical Implications* German journalist Gunter Wallraff posed as a Turkish guest worker in order to investigate workplace discrimination; in his time on a reactor decontamination team, he found that Turkish workers received flimsier protective clothing than German employees. See Gunter Wallraff, *Lowest of the Low* (Mandarin, 1988; German edition in 1985).

Proceedings of a Topical Seminar on the Practical Implications of the ICRP Recommendations (1977) and the Revised IAEA Basic Standards for Radiation Protection, Vienna, 5-9 March 1979, 3. Emphasis mine.

<sup>31</sup> As explained by the ICRP's David Sowby; see Catherine Caufield, *Multiple exposures: chronicles of the radiation age* (University of Chicago Press, 1990), 183.

<sup>32</sup> The term comes from Annie Thébaud-Mony, *Nuclear Servitude: Subcontracting and Health in the French Civil Nuclear Industry* (Baywood Publishing Company, 2011).

<sup>33</sup> Shawna Galassi, "Into The Bowels Of A Nuclear Reactor: They're called Jumpers and they go where no one else will," ([http://archive.newtimeslo.com/archive/2004-01-21/archives/cov\\_stories\\_2003/cov\\_07242003.html](http://archive.newtimeslo.com/archive/2004-01-21/archives/cov_stories_2003/cov_07242003.html)) *New Times San Luis Obispo* Jan 21, 2004.

<sup>34</sup> Writing in the early 1980s, freelance journalist Paul Bagne found that "while electrical output from nuclear plants actually fell from 1978 to 1980, the number of exposed workers grew from 44,000 to 77,000. Of these, nearly half were temporary." It's not clear how many of these workers were involved in the cleanup of the 1979 Three Mile Island accident. Paul Bagne, "The Glow Boys: How Desperate Workers are Mopping Up America's Nuclear Mess," *Mother*

(Mandarin, 1988; German edition in 1985).

<sup>35</sup> In Annie Thébaud-Mony, op.cit.

<sup>36</sup> Notably through NGOs such as the Association Henri P é z e r a t (<http://www.asso-henri-pezerat.org/>) and Santé sous-traitance Nucléaire-Chimie (<http://www.sst-nucleaire-chimie.org/>), sites such as Ma zone contrôlée (<http://www.ma-zone-controlee.com/>), and films such as Arrêt de tranche, ou les trimardeurs du nucléaire (<http://www.franceculture.fr/oeuvre-arret-de-tranche-les-trimardeurs-du-nucleaire-de-catherine-pozzo-di-borgho>) (Catherine Pozzo Di Borgo, dir., 1994), and Alain de Halleux, *RAS nucléaire rien à signaler* ([http://fr.wikipedia.org/wiki/RAS\\_nucl%C3%A9aire\\_rien\\_%C3%A0\\_signaler](http://fr.wikipedia.org/wiki/RAS_nucl%C3%A9aire_rien_%C3%A0_signaler)).

<sup>37</sup> John. M. Glionna, "Japan's 'nuclear gypsies' face radioactive peril at power plants," (<http://www.latimes.com/news/nationworld/world/la-fg-japan-nuclear-gypsies-20111204,0,500190,full.story>) *Los Angeles*

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<sup>38</sup> Sonni Efron, "System of Disposable Laborers," (<http://articles.latimes.com/1999/dec/30/news/mn-49042>) *Los Angeles Times* Dec. 30, 1999. This phenomenon is documented by Thébaud-Mony (op.cit.) and Fournier (op. cit.) for French reactors.

<sup>39</sup> Fournier op.cit.; Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (MIT Press, new edition 2009).

<sup>40</sup> For France, see Thébaud-Mony, op. cit.; for Japan, see Tanaka, op. cit.

<sup>41</sup> Including for Fukushima: The National Diet of Japan, *The Official Report of Fukushima Nuclear Accident Independent Investigation Commission* (Executive Summary), 2012.

<sup>42</sup> Cardis, E. et al., "Risk of cancer after low doses of ionising radiation: Retrospective cohort study in 15 countries," *British Medical Journal* 331 (7508, July 9, 2005): 77, cited in Thébaud-Mony, op. cit., xxii-xxv.

<sup>43</sup> Gabrielle Hecht, *Being Nuclear: Africans and the Global Uranium Trade* (MIT Press and Wits University Press, 2012); Gabrielle Hecht, "Africa and the Nuclear World: Labor, Occupational

Health, and the Transnational Production of Uranium," *Comparative Studies in Society and History* 51/4 (October 2009): 896-926.

<sup>44</sup> Jay H. Lubinet et al., "Radon and Lung Cancer Risk: A Joint Analysis of 11 Underground Miners Studies,"

NIH report 94-3644 (National Institutes of Health, 1994).

<sup>45</sup> Miki Aoki and Jun Sato, "CROOKED CLEANUP (2): Some decontamination workers sorry for following orders," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201301040073>) *The Asahi Shimbun*, Jan. 4, 2013; "CROOKED CLEANUP: Government mishandled complaints about shoddy cleanup work,"

(<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201301050037>) *The Asahi Shimbun*, Jan. 5, 2013; "CROOKED CLEANUP: Government to investigate Fukushima decontamination," (<http://ajw.asahi.com/article/0311disaster/fukushima/AJ201301070080>) *The Asahi Shimbun*, Jan. 7, 2013. At this writing, *The Asahi Shimbun* is running an ongoing series on these practices: readers can search for the keywords "crooked cleanup" to find all the articles.