

## Chapter 4

### DOE Directives and Guidance and ORNL Procedures, 1989-1994

To the lay person -- the nonradiological specialist -- the discussions in this and other chapters of directives and procedures may seem dry compared to the chapters dealing with events. Those who find it tough going can skip it, but I urge rad protection specialists to wade through so that they can see how various functions, especially work planning and the design and operations reviews, were handled at ORNL at various points during the time period 1989-1994 and how this influenced later events.

#### DOE Order 5480.11

As I noted earlier, DOE Order 5480.11, "Occupational Radiation Protection", was issued to take effect in 1989, the year I came to ORNL. The main requirements in this Order were taken from a Federal (executive) directive and as such were supposed to be incorporated in due time into all Federal statutes and regulations, such as the pending revision of 10 CFR 20 that applied to facilities regulated by the Nuclear Regulatory Commission (NRC). One of the new requirements was the establishment of a formal ALARA program. Both DOE and NRC had required the application of the ALARA principle for years. NRC had produced a series of regulatory guides to assist its licensees in applying ALARA in various topical areas; DOE had sponsored the production of an ALARA guidance document by Battelle Pacific Northwest Laboratory (PNL) in 1980 (DOE/EV/1830-T5, revised and reissued as PNL-6577 in 1988). However, there was a difference between the NRC and DOE approaches to application of the guidance. While doing things exactly as recommended in NRC guides was not mandatory for NRC licensees, NRC made it clear that it regarded the guidance as the best or preferred way and that a licensee was expected to implement much or most of it; also, where a licensee chose to deviate significantly from the guidance, NRC expected the licensee to provide justification for the deviation, e.g., on the grounds of inapplicability, use of alternative methods, etc. But DOE made it clear that its guidance was just "good practices" and thus optional.

In my experience, most rad protection people in the nuclear power plant world were familiar with the NRC guides, at least to the extent of having a personal copy of them in a binder. But I found that in the DOE world, many rad protection people had never heard of DOE's PNL-produced guidance document. So before 5480.11, how the ALARA principle was to be applied was not specified by DOE in regulatory form and there were no real requirements for documentation of its application. Thus a contractor company could simply declare itself to be applying ALARA and DOE had no regulatorily fixed way of determining whether that was true or not. On the other hand, DOE could declare that a particular contractor operation was or was not ALARA, on the basis of subjective or even no criteria. ALARA application was therefore an area in which DOE's judgment was often arbitrary and inconsistent -- compliance was in the eye of the (DOE) beholder. This was understandably a sore point for contractors.

There were various schools of thought among contractor personnel as to how DOE ought to proceed regarding ALARA. One extreme position was that ALARA application should be removed from DOE requirements altogether; that is, advocates of this position wanted to be judged only by results (dose figures, number of contaminations, etc.) and not by whether or not they applied ALARA as a process. Advocates of this results-oriented approach tended to stress compliance with statutory limits and to disparage ALARA as "going overboard". At the other end of the spectrum were those who wanted to keep the requirement for application of ALARA as a process and to be judged by how well they applied the process; the results, whatever they might be, were regarded as acceptable if the process was applied rigorously. Advocates of this process-oriented approach tended to stress compliance with program establishment and "good form". The first approach was roughly equivalent to "the end justifies the means" and the second approach to "the means justifies the end".

In DOE Order 5480.11, DOE chose to require the establishment of a formal ALARA program but essentially left it to contractors to specify the form it should take, although DOE promised to provide guidance in the form of new written documents and oral presentations. "Formal" means that the program was to be described by the contractor in writing, including specification of the functions included, who performed the functions, whom the performers were accountable to, etc. It also means that the actions taken were to be documented. Normally, written documentation of a formal program will include a policy statement by site management giving the purpose of the program and management's expectations for achievement of the purpose, including compliance by site workers. A formal program will often have a functional description or charter for the organization that is mainly in charge of managing the program. Finally, a formal program will have one or more procedures that specify who does what and when, where, and how it is done. The Achilles heel of any program is usually the procedures: the program can perk merrily along even if site workers are unfamiliar with the policy and the description, which are often just motherhood statements, but miswriting or misapplication of the procedures can result in program failures.

DOE Order 5480.11 says the following about ALARA and radiological design and operations. (I can't find my copy of the original 5480.11 and have only an archived version from DOE's Web site, the 6/17/92 "change" (revision) of the 12/21/88 original.) The underlining is mine.

"[ALARA]: An approach to radiation protection to control or manage exposures (both individual and collective to the workforce and general public) as low as social, technical, economic, practical, and public policy considerations permit. As used in this Order, ALARA is not a dose limit but a process, which has the objective of dose levels as far below applicable limits of the Order as reasonably achievable....It is DOE's policy that exposures to radiation resulting from DOE operations be maintained within limiting values....and as far below all limiting values as reasonably achievable....Plans and programs used to assure that occupational radiation exposures are maintained ALARA shall be documented."

"Design and Control. Radiation exposure rates in controlled workplace areas should be reduced to as low as reasonably achievable levels by proper facility design and control. The primary means for maintaining exposures as low as reasonably achievable are to be through physical controls, e.g., confinement, ventilation, remote handling, and shielding. Administrative controls and procedural requirements are to be considered supplemental means to achieve control."

"Design. During the design of facilities, the following objectives shall be applied: (a) Optimization. Optimization principles, as discussed in ICRP Publication 37, are to be utilized in developing and justifying facility design and physical controls. (b) External Radiation Exposure. The design objectives for personnel exposure from external sources of radiation in continuously occupied controlled areas are ALARA and not exceeding 0.5 mrem (5 microsieverts) per hour on average. The design objectives for exposure rates for potential exposure to a radiation worker where occupancy is generally not continuous are ALARA and not exceeding 20 percent of the applicable standard.... (c) Internal Radiation Exposure. As a design objective, exposure of personnel to inhalation of airborne radioactive materials is to be avoided under normal operating conditions to the extent reasonably achievable. This will normally be accomplished by confinement and ventilation."

"Records of ALARA programs shall be maintained by field organizations and operating contractors to demonstrate the adequacy of the ALARA plans and programs and their implementation....Contractor internal audits of all functional elements of the radiation protection program shall be conducted [including the] ALARA program."

All of these requirements were supposed to be incorporated into the site rad protection program by about 1990. The reader should note the use of the word "reasonably", which implies the application of

judgment. Note too that while physical controls, such as shielding and ventilation, were to be preferred over administrative and procedural controls, how this was to be determined was left largely to the contractor's judgment.

5480.11 also did not specify who was to perform ALARA determinations, or what their qualifications and functions should be. I believe that this was for several reasons. First, the application of ALARA -- the ALARA process -- clearly was a collective endeavor that would involve both the operating and rad protection organizations. For example, a site administrative dose limit that was set below the regulatory limit would be produced as a collaborative effort on the part of both the operating and rad protection organizations, typically by their representatives on an ALARA or rad control committee. For a particular operation, this administrative dose limit might be too limiting, given the importance or urgency of the work to be done; then a higher operation-specific limit might be set.

Second, within the rad protection organization, the ALARA process would involve all levels and kinds of rad protection people. For example, for a particular job there might be additional administrative controls, such as using two dosimeters or sending the official dosimeter (TLD) off to be read when a worker was approaching 90% of the dose limit as measured by real-time dosimeters (e.g., self-reading dosimeters). These administrative controls would be specified by a health physics supervisor or rad engineer and administered by him and/or the rad techs covering the operation. The dosimetry people might have to be consulted as to feasible turn-around times for dosimeter readout, representative TLD positioning, etc.

Third, DOE sites were organized differently, both in their operational and in their rad protection groups. The distribution of functions and titles within the rad protection organizations varied. DOE did not want to dictate that certain titles perform certain functions, etc., because that might require reorganization on the part of contractors, which DOE would either have to pay for or hear gripes about.

So DOE, probably to accommodate the multiplicity of involvement in the ALARA process and to allow the contractors latitude in applying the process, merely directed that ALARA be applied and left it to the contractors to determine how.

#### ORNL Health Physics Procedures, Circa 1989

An ORNL health physics procedure manual from 1989 is interesting in light of what followed in later years. This manual, like all later ones, was addressed to both the rad protection organization and to the rest of ORNL. It stated repeatedly, in both the policy procedure and the topical procedures, that the ALARA principle was to be applied. Since some of the procedures dated from before 5480.11 was issued, this requirement clearly was not new. One procedure in this manual covered the ALARA program and various groups had ALARA fulfillment responsibilities, but there was no particular ORNL staff member who was the ALARA honcho and no group that coordinated the ALARA effort. Environmental rad protection (of the public and the environment) was part of the ES&H division along with occupational rad protection (i.e. of the worker), thus providing coordination of the two rad protection "wings". Consequently, the radiological-related requirements for both were in this manual.

Line management -- the operating or research (O&R) division management -- was said to be responsible for the radiological safety of those working in its facilities. This included pre-approving an individual's exceeding the weekly or quarterly administrative dose limits. However, approval by the rad protection organization, the nuclear safety organization, and/or the independent Director's Review Committees was required in many areas, e.g., in the design of new facilities and the modification of existing facilities, in nonroutine operations, and in setting radiological goals and administrative dose and contamination limits. Although ES&H was said to serve in an "advisory capacity" to or to "assist" operating divisions and Laboratory management, the rad protection organization was nevertheless responsible for reviewing and apparently approving various specific kinds of facilities (e.g., X-ray facilities), determining the radiation

hazards in work areas, and specifying working times and other protective measures. The rad protection organization also "certified" (approved) Radiation Work Permits (RWPs), along with the O&R supervisor. Special approvals (by the O&R division director, the ES&H director, and the ORNL associate director, depending on the level) were required to exceed administrative dose rate or dose limits. ALARA goals were to be set by O&R supervisors in consultation with "radiation protection staff" if doses were expected to exceed certain levels. An undefined "ALARA reviewer" identified ALARA actions, kept track of the work, and conducted a postjob review.

ES&H was also to review, comment on, and advise regarding other divisions' procedures; if any part of any division's procedures did not comply with ORNL rad protection requirements, that deviation had to be approved by ES&H and the Laboratory Executive Director. Nonroutine radiation and contamination survey frequencies were to be set by the O&R supervisor and the "area health physicist". (By the wording and the invoking of one of the technical appendices, this latter person was apparently not a rad tech or complex leader but one of the professional health physicists or rad tech group leaders). The rad protection organization also set the maximum operational contamination limits, to be observed in all areas of ORNL. These limits were to be based on six specified criteria, e.g., the probability of transfer of contamination. A hazards evaluation was to be done by line management for each operation that might involve significant radiological hazards; this was subject to review by the Director's Review Committees. There was an ALARA Committee that was to review facilities and operations (against ALARA design goals); personnel exposures; and changes to health physics procedures. The rad protection organization was to assist this committee by identifying radiologically significant work groups, locations, and tasks.

Stopping work was done by the O&R division management, although one procedure did state that any worker could stop work. A stop-work override could be authorized in emergency circumstances by the O&R division director, apparently without the concurrence of the rad protection organization. Except for this case, the manual was silent on who could authorize restart of operations after work was stopped. The manual stated that the rad protection representative could recommend to the O&R supervisor that nonemergency work be stopped, e.g., when there might be "unnecessary" personnel exposures or "loss exceeding \$5000". The representative could "escalate recommendation-of-work-stoppage to higher levels of supervision when ignored by the operating supervisor", with the O&R division director's approval being necessary to override the representative. Note that the authority to continue work in the face of decided hazards was left in the hands of the O&R people. Note too the apparently arbitrary dollar figure cited as a criterion for recommending that work be stopped; this sort of criterion is hard to apply because it would require that a quick and probably very rough estimate be done. On the other hand, when a radiological (adverse) incident occurred, line (O&R) management was to inform ES&H immediately and in detail. ES&H -- not line management -- was responsible for categorizing the incident as minor or serious. Criteria for a serious incident included "willful and repeated violation of rad procedures".

Detailed guidance was given in the manual's various technical appendices, obviously written by professional health physicists and engineers. Much of the guidance consisted of equations and explanations of the factors affecting decisions on the topics covered.

Thus we see that this 1989 pre-5480.11 manual did invoke ALARA, but did not establish a formal program that included an individual or group who was responsible for, e.g., tracking dose; this was left nebulously in the hands of multiple groups around the site, with much apparent duplication of effort. There was little specific reference to professional health physicists and none at all to rad engineers, with the design and operational review responsibilities of the rad protection organization assigned vaguely to "ES&H" or the "Radiation Protection Department". These fuzzy references obviously allowed for flexibility of assignments on the part of the ES&H organization, but potentially they also allowed for unqualified people to be assigned and for things to fall through the cracks (on the grounds that some other group would be reviewing it). Line management had a great deal of authority in keeping the work going

in the face of problems, but still was accountable to the independent Director's Review Committees and the nuclear safety organization; was accountable in certain key ways to the ES&H organization, notably in the area of incident reporting and RWPs; and was accountable to some extent to the ALARA Committee (half of whose members headed O&R divisions). Even so, as ORNL lore indicated, many shortcomings had never been remedied and various incidents had been swept under the rug. This was part of the DOE site safety culture that DOE was trying to remedy in promulgating 5480.11.

These problems would not be remedied by 5480.11 per se since it was relatively unspecific and toothless. But the establishment of an ALARA program could help, if it did not merely nibble at the edges of dose reduction but combined informed review of radiological features of designs and operations with close tracking of doses and contamination. This meant that ORNL would have to establish a rad engineering or senior health physics group that performed these functions, as Swanks and Setaro seemed to recognize. That appears to be the reason why Setaro began to set up the ALARA Program group as he did. However, he was only a commenter on the health physics procedures and could not dictate their content, while Swanks did not seem inclined to push too hard on the rad tech organization headed by Butler.

#### The ORNL Health Physics Procedures Revision of 1990

In January 1990, comments were solicited on a revision to the ORNL Health Physics Procedures Manual that would incorporate those 5480.11 requirements not already included. Most notable to me, as a rad engineer, was Procedure RP-6.3, "Facility and Equipment Design". The proposed revision of RP-6.3 stated that ES&H "provides technical expertise and guidance...regarding design and operation of facilities and equipment involving radioactive materials or radiation-producing [sic] devices...[including] shielding...monitoring instrumentation, [and] review of equipment layouts to minimize exposure". The duties of the ALARA Program Manager were now listed separately from those of ES&H as an entity, as if he and his staff were not truly considered to be part of ES&H. Yet much of the technical expertise and guidance were now said to be coming from the ALARA staff, especially "to minimize exposure". As became clear later, the partitioning of the work in this manner contributed to Butler's retaining within his organization nearly all rad engineering functions, leaving the ALARA staff only a limited and nominal involvement.

A similar limitation of the ALARA staff was evident from two other provisions of RP-6.3 about design and procedure reviews. It stated that while the Laboratory Director's Review Committees "review proposals for new facilities and procedures or changes of [sic] existing facilities and procedures involving radioactive materials or radiation-producing devices", the ALARA Program Manager "reviews and approves the ALARA design features for new construction and or modifications that involved capital expenditures greater than \$250,000" and "provides input to the conceptual design of facilities". The reader should note that the word "reviews" used in reference to a committee usually means the committee has an approval function, while "provides input" usually does not imply any approval authority. The Director's Review Committees always included an accident safety person but might or might not include someone from rad protection. (As I noted earlier, the Reactor Operations Review Committee did not have a rad protection member until I joined it.) So if new construction or modifications involved capital expenditures of less than \$250,000, no rad protection specialist would necessarily be involved in the independent review, whatever the dose or contamination potential. I therefore commented that it should be the anticipated dose, not the money expended, that should determine the inclusion of the ALARA staff in the review.

It was also proposed to state that optimization "shall be considered". In the regulatory world, "shall" means "must" or "have to"; "should" means "ought to" or "is to be done in the normal case"; and "may" denotes an option. However, if the "shall" is coupled with option-permitting words and if the "should" is not buttressed with decision-making guidance, then provisions that include these words can degenerate to largely optional status. Of course it is not appropriate to do a complete optimization analysis in every

case, or even in most cases, so it was inappropriate for the word "shall" to be used so generally in RP-6.3. But there was also no guidance in RP-6.3 as to when optimization was required or who would make the call regarding the necessity for it. So although 5480.11's use of "shall" for optimization was included, the use of the word "considered" reduced the requirement to something optional: some unspecified reviewer could think it over and dismiss any need for it and, apparently, would not need to document why.

It was also proposed that the design team of specialists who would do the conceptual (broad initial) design "should" include an ALARA representative. Again, this was not stated as being required however high the anticipated dose or contamination potential might be. So any review by an ALARA person (or rad engineer) could be deferred until after the design was complete, when there would be difficulty in and resistance to changing the design to improve radiological outcomes. True, it was stated that "The ALARA Manager or his designated representative should provide a review and approval at each stage of the facility design...normally includ[ing] preconceptual design,...conceptual design,...safety assessment document,...", etc. But this was not the same as being on the design team and in any case, this was only guidance. The "should" ensured that the review and approval could be dispensed with when desired.

The one tight requirement for ALARA Program involvement given in the proposed RP-6.3 was that the ALARA Manager "shall approve the completeness [sic] of the designed safeguards, including redundancy, fail-safe features, interlocks, and alarms". However, another provision was that the Director's Review Committees "shall conduct ALARA reviews of new facilities", including the location of radiation sources away from occupied areas, providing remote-handling equipment, designing surfaces for easy decontamination, and establishing shielding and containment requirements -- all of which have ALARA implications. So this seemed backward, in that the Committees generally concentrated their reviews on provisions that prevented serious accidents and thus serious dose, such as the cited safeguards would prevent, while one would have thought that the ALARA Manager was supposed to conduct ALARA reviews and focus on ALARA measures for dose reduction. I thought that there would definitely be value added by having the Committees do an overall radiological safety review, but their review should have been preceded by a rad protection specialist review.

In the proposed RP-6.3, there was a section called "ALARA and Radiological Design Criteria", as though radiological design and ALARA were distinct concepts. This was an alien thought to me, as a rad engineer, because I regard rad protection as a continuum from the "drastic accidents" down to the minor dose reduction possibilities. But at least the references included DOE Order 6430.1A, "General Design Criteria", and PNL-6577. The former, an omnibus design guidebook, filled a thick binder and covered a multitude of topics from finance to railroad frogs in encyclopedic breadth and it gave many particulars of good radiological design as "shalls". The specific dose and dose rate limitations of 5480.11 were given in this RP-6.3 section as design requirements, thus providing some specificity in this way also.

Finally, the proposed RP-6.3 had an appendix called "Design Review Considerations", which had been copied from some reference. One item was "Verify that shielding meets ALARA requirements". I commented that it was best not to refer to ALARA "requirements" since there are no absolute numerical ALARA limits. I suggested "radiological requirements", "design criteria requirements", or "ALARA guidelines". Here, as in future revisions of health physics and other sets of procedures, one saw authors that were "unclear on the concept" of ALARA. Yet as I will observe here and elsewhere in this book, nearly everybody at ORNL seemed to think he was an ALARA expert: it was such a simple concept that of course absolutely anybody could apply it.

Despite my reservations, I did not comment on the lack of specificity regarding who was doing what in this procedure, except for the item about the ALARA Program Manager reviewing cases where more than \$250,000 would be expended. Being the new kid on the block, I thought it inappropriate to criticize that sort of thing until I saw how it all worked in practice.

5480.11 required an assessment (audit) of the rad protection program every three years, so it was decided that in the first year, four or so different subject areas would be assessed, leaving the rest for the second and third years. Thus in February 1990, John Alexander, a certified health physicist in the nuclear safety organization, issued a proposed set of criteria for assessing the first four subject areas, including ALARA, against 5480.11 requirements. Alexander capably captured the major aims and requirements of 5480.11 in the form of yes-or-no statements, such as "The program requires monitoring and analysis of exposure trends and comparison of actual radiation dose with established goals". In my comments on his criteria, I observed that many of the criteria were not in the procedures and therefore were not necessarily being done ORNL-wide. Since audit findings not based on actual commitments can generally be ignored, I thought that this showed a deficiency in the procedures, not in Alexander's criteria.

#### ORNL Health Physics Procedures, Circa 1992-Early 1994

The next copy of the ORNL rad protection procedures (RPP) manual that I have is dated early 1994. The procedures were numbered as they had been in the 1990 version and were, by their revision dates, mostly the same as in 1990. But this revision incorporated many of the changes that were necessitated by the startup of the ALARA Program, the hiring of Kurt Geber and Rich Utrera as "radiological engineers" in the rad tech section, and the advent of the Rad Control Manual. Changes regarding the latter were not fully incorporated into the ORNL RPP manual until well into 1994 and so will be discussed later.

In this 1994 manual, the policy procedure (still dated 1989) now stated that copies of documents, such as operating procedures, related to rad protection in operations "should" be furnished to the appropriate complex leader (i.e., rad tech supervisor). Although the "should" made it optional and there was no complex leader review or signoff required, this nevertheless recognized a "need to know" on the part of the rad protection organization. The policy procedure also stated that it was the complex leader's responsibility to "assess the hazards of each operation" and "advise on the radiation safety aspects of operating procedures". There was no documentation requirement for the hazards assessment, however.

RP-1.3, on rad protection in the design of experiments and plant operations, was dated October 1991 and referred to the rad protection organization as the "Office of Radiation Protection", a name it would retain for nine more years. RP-1.3 stated that the rad protection organization "conducts reviews of submitted operating procedures" that "should" be offered to the area RPS representative for review -- but only to ensure that they did not conflict with the health physics procedures. RPS was the "Radiation Protection Section", i.e., the rad tech organization, thus the rad tech complex leader or group leader would be the reviewer. RP-1.3 also referred to DOE Order 6430.1A (see above), but in the "Design Requirements" section, a former reference to "two lines of defense" was removed from the subsection on radioiodine use. The new requirement, where 5 mCi or more was used, was that an experiment or operation be "adequately protected" with a charcoal absorber "or equivalent". Who decided what was "adequate" or "equivalent" was left unspecified. However, a reference to two lines of defense in the general facility design section was retained and the former statement that shutdown "should be considered" if one of the lines of defense failed was changed to a "shall" plus an exemption clause (with O&R division director authorization).

An area substantially beefed up in the procedures was the division radiation control officer (DRCO) program. I am not sure why this was done, but it is clear from the new RP-1.7 (dated 1993), that the DRCO was intended to assume a prominent role in the rad work activities of his O&R division. The intent also seemed to be to create a representative of the O&R division director, because the DRCO answered directly to him, and to create a single point of contact for the interaction between the O&R division and the rad protection organization. RP-1.7 stated that the DRCO "shall be a professional staff member or a highly qualified technician with radiation safety expertise", but the qualifications were not specified even by example. The DRCO "should" be "independent of most division operations and experiments using radioactive materials or producing radiation" and also "independent of operations and experiments for

which he or she conducts oversight". The DRCO was to have "authority to impose **any degree** of limitations on all division experiments, operations, and services involving radiation" (the bolding was in the procedure). The DRCO was required to be trained, although the training was limited to the same training as users would receive (e.g., if the division had contamination areas, the DRCO was required to take Rad Worker II training, the same as contamination area rad workers). Divisions that did no rad work were still required to have DRCOs, but these DRCOs initially did not have to be trained. Special training beyond this was eventually produced and provided at the behest of Alexander. Alexander had the newly created part-time position of "Division Radiation Control Officer Liaison". In addition to organizing and presiding over monthly meetings of the DRCOs, he was authorized by the procedure "to determine if a proposed experiment or operation referred to him by a DRCO exceeded the bounds of approved safety documents" and to advise the O&R division regarding sending the request for review to the nuclear safety organization. He was also supposed to participate in "at least one review or inspection" of an operation or experiment annually and in investigations and reviews of unusual occurrences with radiological impact.

The effect of this procedure was thus to create a required position for a person in each O&R division who, as DRCO, would specialize in rad protection as a quarter-time or half-time activity. However, he would not necessarily have any special training in rad protection beyond what users received, although he might have had experience as a researcher or other worker in experiments or operations with some radiological hazards. The division line managers, according to the procedure, were supposed to "submit plans for new operations or experiments...or modifications" to the DRCO for review and to copy the DRCO liaison on notifications of radiologically related occurrences. The DRCO was to provide advice and recommendations to everybody from division director to experimenters and support workers; to advise division managers on ALARA goals; to review procedures and recommend inclusions of ALARA considerations in planning operations and maintenance; to review rad safety aspects of all new or modified operations and experiments or to ensure competent, independent division-level review (or he "may request" assistance from ORP); and to provide "oversight" of line supervisors' management and control of worker exposures. Even more significantly, the DRCO also was empowered to decide when an operation or experiment required rad safety review and approval in addition to those by division staff and the area rad protection representative (rad tech or complex leader); to send requests for external reviews to the DRCO liaison; and to "agree with the area rad protection representative on generic criteria and action levels (i.e., minimum levels of dose rate, dose, surface contamination, airborne contamination, etc.) that required notification of the DRCO and the area rad protection representative" by the line manager.

The implications of vesting such authority and responsibility in a person with no special training in rad protection, appointed by the division director (i.e., O&R management) will be illustrated in later chapters. While the intent was good -- i.e., buy-in by line management through safety advocacy by a member of their own division -- the effect was that the divisions could resist review and oversight by the ES&H organization because they could claim it duplicated what they were already providing internally. Also, if the need for a review of an operation by ORP had to be determined by a person within the O&R division, then this decision could be manipulated to allow for evasion of the review. Finally, many radiological criteria and ALARA determinations were to be determined on an operation-specific basis by this division rep and the local rad tech or complex leader -- not by, say, a rad engineer or professional health physicist.

RP-2.5, "Contamination Control", reiterated the requirements of the procedure it superseded. But the rad tech organization now was to "serve in an advisory capacity" to the O&R divisions in matters involving contamination control, to "recommend" decontamination procedures, to review personnel contamination reports and investigate events, to evaluate jobs and working conditions and "recommend" control measures and procedures, and to sign RWPs. The rad tech section was given ("shall") the authority to establish the "maximum operational contamination limits" that were to be observed in all ORNL areas and activities. This procedure stated that the RWP was the "primary means" of documenting not just radiological conditions, but also rad protection requirements for "significant work in the Controlled

Area". Note that although ALARA was invoked in this procedure, there was no role at all indicated for ALARA staff, rad engineers, or senior health physicists outside the rad tech organization.

RP-2.8, on X-ray-generating equipment, now stated that the DRCO was involved in the process: he was to "provide general oversight" for X-ray related activities and to "verify that supervisory requirements are executed [sic] so as to maintain workplace safety". But there were still extensive provisions showing that as before, the rad protection organization was involved in and had authority over all aspects of X-ray surveys, monitoring, and design verification (along with the instrumentation and control people who tested the equipment). By contrast, RP-2.13, "Radiation Protection Guide for High-Level Radiation Facilities", stated that "safeguards for sealed sources and radiation-producing devices which generate dose rates less than 1 rem/hr will be specified by the DRCO", although it did invoke DOE Order 6430.11 in a limited way. The rad tech section was to "assist" line supervision in the planning and design of new programs and facilities, to review the design of new facilities, to "assist supervision in the development of effective methods of preventing unnecessary exposure to radiation", and to "promote the ALARA philosophy and encourage" ALARA practices. The DRCO was to "verify that supervisory requirements are executed"; line supervision was to maintain the ALARA program documentation. Notably, it was the DRCO, and not a review committee or the rad protection organization, who was to specify safeguards for radiation facilities up to 1 rem/hr. The rad tech section was to review and presumably have approval authority over his choices and presumably a Director's Review Committee was to review any new or significantly modified facilities, but the rad (ALARA) engineering group was not assigned any role at all even though ALARA and shielding were important aspects of their part of the rad protection program.

RP-2.16, "Guidelines for Radiochemical Laboratories" (still the same as in 1990), stated that its purpose was to establish a laboratory classification system that "may" be used by line supervision in determining the degree of confinement that "may" be required for the radionuclides that were handled or processed in a laboratory; supervision "may" then use the system as a guide to determine the type of laboratory and the containments that were necessary. This procedure was a transformation of a former appendix (A-7) of the 1989 version, which as noted above contained requirements and not optional "may" statements. RP-2.16 now stated that the requirements were to be contained in "facility safety documents", i.e., in operation- or facility-specific documents. Yet the new procedure also stated that "this procedure [RP-2.16] provides a guide..." and that "This procedure serves not only to specify requirements for laboratories but also to provide guidelines...". Apparently the requirements from, e.g., DOE Order 6430.1A were the firm requirements, while everything else -- mainly the classification and containment schemes -- was "guidance". But the procedure stated, e.g., that "Radiochemical operations requiring Type A laboratories....shall be conducted in gloveboxes or hot cells", etc. Thus the applicability of any given provision to a specific facility was unclear -- was it a shall, a should, or a may? This procedural change was troubling because it shifted to line supervision the responsibility for adopting the classification scheme, instead of, again, a review committee or the rad protection organization. The Martin Marietta Energy Systems (MMES) Engineering Division -- which at the time served K-25, Y-12, and ORNL -- was to assist in determining what DOE Order 6430.1A requirements applied. But the DRCO was to "approve changes in activities". Thus after the startup of the facility, the DRCO appeared to have sole approval authority for changes. Although this procedure itself was dated 1990, a correction dated October 1992 shows that it was in use at least up to the latter date.

RP-3.1, "Radiation Protection Standards" (dated 1993), replaced the former "recommended" ORNL administrative limits of 1/3 of the maximum quarterly dose per quarter and 100 mrem per week. Based on the goal of keeping radiation exposures at "a small fraction" of the quarterly limits, annual administrative guidelines were set at about 1/3 of the annual whole-body limit of 5 rem -- or 2 rem -- with corresponding guidelines for the lens of the eye and other organs. There were guidelines of 100 mrem per week and 20 mrem per day to the whole body, with corresponding figures for the lens and other organs. Other figures, effectively limits, were given as being permissible with the approval of the line supervisor, the division

director, and the rad protection director, depending on the level and time interval over which the dose would be received. No ALARA review was required as a condition of going to higher doses.

RP-3.6, "Radiation Work Permit" (dated April 1992), defined an ALARA review as "an ALARA briefing, a prejob review, or a postjob review by line supervisors, line management, radiation protection staff, and ALARA program representatives". (Again, this implied that ALARA program representatives were not part of the rad protection staff.) Under "Responsibilities", the facility manager, the supervision, the rad tech section, and the radiation worker were all mentioned -- but not the ALARA program staff. In the body of the procedure, the rad tech organization and line supervision were jointly charged with producing the personnel dose estimate that would be attributed to a job or an extended operation. The ALARA staff representative was not included as one of the signatories on the RWP. There was a table (reproduced below) that gave requirements for the ALARA review. The procedure stated this: "When ALARA review requirements are specified, the rad protection representative supplies the Radiological Engineering Group of the RPS [rad tech section] and/or the ALARA program representative with the survey information for use in ALARA evaluations". This statement indicates that the rad protection representative and line supervision together made the determination as to whether the requirements of the ALARA review table were met or not. Thus it was possible for line management and the rad tech section to exclude the ALARA staff under the "and/or" provision, although that was perhaps not the intent of the author. This was the first procedural use of the term "RPS Radiological Engineering Group" (i.e., Geber and Utrera, under Butler) and the first appearance of the ALARA review table (below) that was eventually to be such a bone of contention in rad review. (The reader should note again that the "RP rep" would generally be a rad tech.)

**RP-3.6's ALARA Review Requirements Table (Circa 1990)**

<u>Review Category</u>	<u>Short Job, Person-Rem</u>	<u>Campaign, Person-Rem</u>	<u>Review Requirements</u>	<u>Participants</u>
Level 0	D < .3	D < 1	None required	N/A
Level 1	.3 ≤ D < 1	1 ≤ D ≤ 5	ALARA briefing	Group I
Level 2	1 ≤ D < 3	5 ≤ D ≤ 20	Prejob review w/ ALARA briefing	Groups I & II
Level 3	D ≥ 3	D ≥ 20	Prejob review w/ ALARA briefing and postjob review	Groups I-III

Group I: Radiation Protection (RP) representative, ALARA Program representative, line supervisor, workers  
 Group II: RP complex leader, Radiological Engineering representative, facility manager  
 Group III: RP group leader, O&R division director, ALARA Program manager

D: Collective dose  
 RP: rad tech section

Short job: Less than 24 hours  
 Campaign: Extended operation (more than 24 hours)

The procedure also stated that line supervision "shall" ensure that controls and procedures were in place by "coordination with" the rad tech section. Thus it was line management that was to provide the verification of the controls, with no required verification by rad protection. The division director was allowed to delegate RWP approval, when his approval was required, to his DRCO. ALARA goals for the work were to be set by "[O&R] supervision, in consultation with radiation protection staff", which, as noted, did not necessarily imply inclusion of ALARA Program staff. The procedure said of the postjob review that the worker exposure "should be reviewed by management". Only if the dose totals "exceed ....guides [given above]" did a formal postjob review have to be performed ("shall"). But this was confusing because the guides were a trigger for the prejob reviews and the controls. So this could be taken to imply that a postjob review had to be performed only if the resulting doses turned out to be at a level

above that for which the job or campaign was originally reviewed. The procedure also said that a review of the steps "shall" be performed if "actual exposures were found to be higher than anticipated" (how much higher was unspecified). Thus it was unclear how to apply these provisions.

The procedure retained the provision for "posted regulations", a widely used substitute for RWPs. A posted regulation was simply a statement of the provisions for accessing and working in an area, such as would be found on an RWP, but without the necessity for a worker to read and sign in each time. The procedure explicitly allowed for posted regulations to be used for anticipated individual doses up to 50 mrem/week or a collective exposure of 1 rem/month; they could not be used for entry into Very High Radiation Areas, but could be used for High Radiation Areas (greater than 100 mrem/hr). There was no contamination limitation other than that the area be well characterized. DOE regulations later eliminated use of the posted regulation except for very low-level areas, but at this time they were still widely used.

RP-4.2, "Radiochemical Glovebox Safety", required the nuclear safety people, the industrial safety people, and the DRCO to participate in a readiness review of new gloveboxes. Procedures specific to the new glovebox and its intended operation were required. Although the rad protection organization was not involved in the readiness review, they were responsible for advising as to the adequacy of gloveboxes for the work to be done and for reviewing the procedures used.

RP-6.1, "ALARA Radiation Protection Program", stated explicitly that the rad tech section, along with the rad dosimetry and records section, "complements the ALARA Working Committee in a matrix support function with responsibility for operational radiation monitoring, surveillance activities, technical support, and radiological engineering". Strangely, the ALARA Steering Committee was not mentioned. The ALARA Program was said to "support the committee structure by providing analytical support and required information analysis". However, what this analysis consisted of was not stated -- nor was the ALARA review function given in the procedural steps. Meanwhile, in the "Responsibilities" section, the Rad Engineering group in the rad tech section (again, Geber and Utrera) was said to review the following: rad work documents for jobs "in accordance with [unspecified] ALARA review requirements"; maintenance or operating procedures for "adequate radiation protection"; "plans for temporary shielding"; and "design of special tools and equipment that reduce job time...". They were also to "provide technical analysis support for radiation protection problems", "write health physics procedures...to incorporate ALARA based on lessons learned", and "develop and implement radiation work practices, procedures, and engineering controls". Thus it is clear that all of the technical ALARA problems (such as how much shielding is adequate) and much of what is traditionally ALARA specialist work were to be done by the rad tech section radiological engineering group without any formal or required input from the ALARA Program staff except when an RP-6.1 review level might be triggered. Even then, the review would be after the fact and not during the design or operational planning phase.

The one area where the ALARA Program had any teeth was in the provision for an ALARA plan. A formal ALARA plan could be "required for selected campaigns at the discretion of the ALARA Program Manager" and he implicitly had approval authority. The candidates for these plans were "Jobs...[that] may involve, for example, complex evolutions with items which are likely to be very radioactive, situations in which the radiological conditions are likely to change significantly during the course of the job, or any other task for which the ALARA Program Manager believes that a formal ALARA plan could result in a significant exposure savings". This obviously conferred a strong albeit limited power on the ALARA Program manager.

RP-6.2, "Personnel Exposure Control" (dated 1990), explicitly gave the rad tech section the lead role in the nondosimetry parts of the procedure. The rad tech section rad engineering group was to "support the ALARA Program by providing radiological engineering to specific jobs or campaigns" and "The primary focus of the Radiological Engineering group shall be to seek and implement exposure-reduction methods

for work that takes place in radiological areas, through the practical use of innovative techniques, special tools, engineered containments, portable ventilation, temporary shielding, or administrative controls". Further, the rad tech section would provide support as requested by local line supervision "for recommending and implementing methods designed to reduce exposure". The complex leaders were to assist local supervision and the rad engineers in estimating exposures prior to the start of work. The planning of work by O&R divisions "shall be performed in accordance with ALARA review recommendations of the RPS staff or the ALARA Working Committee, as approved by facility management". The ALARA Program manager was the only ALARA Program staff member mentioned as having any responsibilities in this procedure (whose topic, remember, was "exposure control"). He was to "review the content of ALARA training" and "make suggestions for improvement"; "conduct surveillances of ALARA activities...including an annual surveillance of RWPs"; and "periodically observe jobs in progress" -- i.e., a totally audit/assessment function. But no review or approval provisions and no involvement in daily work were mentioned (except obliquely, via a mention of RP-3.6, on RWPs).

This procedure shows that the rad tech section was being allowed to retain all serious dose-reduction prejob planning and control-prescribing functions, rather than having the ALARA staff be involved. Again, although at the start of the ALARA program it was the expectation that many or most of the rad engineering functions would be performed by the ALARA Program staff as part of their review of dose reduction issues, this procedure took them out of the ALARA Program and put them in the hands of the inexperienced rad tech section rad engineers. At no point was it suggested in this procedure that people with ALARA questions should refer them to the ALARA Program manager. Finally, the statement implying that "ALARA review recommendations of the RPS staff or the ALARA Working Committee" had to be approved by facility (line) management before implementation or adoption was distressing.

RP-6.3, "Facility and Equipment ALARA Design", stated that the Environmental and Health Protection Division (group or section unspecified) was to provide "technical expertise and guidance regarding design and operation of facilities". The ALARA Program manager was said to "review and approve the ALARA design features for new construction and modifications that involved capital expenditures greater than \$250,000". Again, the ALARA manager's involvement was limited by an arbitrary dollar figure without reference to dose or contamination potential. Again, he was supposed to "provide input to the conceptual design phase" and "serve a coordinating role among diverse operation, radiation protection, and engineering groups" having ALARA input. He was also to provide "a review and approval at each stage of the facility design", but this was only a "should" statement. The one ALARA Program "shall" was that the ALARA manager "shall approve the completeness of the designed safeguards", including interlocks. As noted for the previous revision, this was odd since it was the Director's Review Committees that normally looked at such acute-dose-related features. Conversely, the procedure stated that these committees and the nuclear safety people were to conduct formal ALARA reviews of new facilities and ongoing nuclear operations, which had apparently not been required before. In this procedure, there was most often no indication who was to perform the various required actions. Thus, for example, it was stated only that "Optimization (ALARA) ....shall be considered". The "design review team of specialists that integrate the various disciplines" was to "include an ALARA representative", but only as a "should". And again, many specific features were mentioned, either as requirements from 5480.11 and 6430.1A or as recommendations (an appendix), but their implementation mode was left fuzzy.

In RP-6.4, "ALARA Education and Training" (dated 1990), there was no mention of the ALARA Program, even though RP-6.2 stated that the ALARA Program manager was to review the content of ALARA training. The section on ALARA training stated in several items that ALARA training might ("may") be provided to a worker by the O&R supervisor or by a person already qualified in the [operational] procedure, with the documentation for this training to be done by the O&R division. Thus line management was procedurally allowed to give its own self-determined "ALARA" training, without any requirement for submission of it for review or approval to any rad protection representative.

In RP-6.5, "ALARA Program Evaluation", the purpose was said to be to "describe...the methods and processes for making assessments and evaluations to reduce personnel exposure potential". Its applicability was to "the ALARA program elements of equipment design, exposure control methods, training,...and exposure accounting and evaluation methods". The ALARA Program was said to provide "dedicated technical support to the ALARA Program [sic]". The ALARA Working Committee was again said to have as a responsibility to "review Laboratory operations identified as having a significant radiation exposure potential", while the ALARA Program manager was again to review the content of ALARA training, perform audits of ALARA activities, etc. The rad tech section was listed only as "assisting" divisions in setting ALARA goals and in implementing health physics procedures. So it fell again to the Director's Review Committees to "provide routine oversight and evaluation of operations and experiments to ensure that they comply with the ALARA principle". The ALARA Program was to ("shall") "conduct assessments within the specialty [sic] of the ALARA Program Office representative". In this procedure there was again the odd assignment of ALARA compliance oversight to the Director's Review Committees, when they had not traditionally been assigned this area. Also, what the "specialty" of the ALARA Program was was left vague.

In this revision of the rad protection procedures, the appendices were still included but were labeled even more explicitly as only guidance. This was especially true of the one on surface contamination levels, since the numerical limits were superseded by DOE 5480.11. However, their discussions of the factors affecting the choice of increased control or extra measures apparently were still regarded as worthwhile information at this time.

A final summary note about this revision of the health physics procedures: as in the earlier version, ALARA was invoked in nearly every procedure, but the ALARA Program staff had no explicit involvement in the work planning process, the operational review process, or in design and modification except in the few procedures noted. Thus the rad tech section, which included mostly rad techs and their supervisors, retained virtually all of the analytical and criterion-setting authority. At the time this set of procedures came out, those who could be said to be doing the rad tech section senior health physicist and rad engineering functions were one or two professional health physicists a few years away from retirement who were used on an ad hoc basis (since they were also complex or group leaders) and the two relatively new "rad engineers" (Geber, with only hospital nuclear medicine experience when hired in 1990, and Utrera, with essentially no experience when hired in 1991). Also, with the advent of the DRCO, line management had a functionary on whom was conferred some of the review and authorization power that otherwise might have been given to the safety organization (rad protection and/or nuclear safety). Although this was due in part to DOE's desire to get line management to take responsibility for safety, one effect was to foster the formation of so-called "shadow" safety organizations within the divisions: part-time safety specialists, often with no professional safety qualifications or training and experience as safety specialists, who took over safety oversight duties and authorization responsibilities within their divisions. As we will see, this was often at the expense of oversight by the "regular" safety organization.

#### The 1991 DOE Rad Protection Conference (Knoxville, Tennessee, 27-29 August 1991)

At other DOE sites, most significant or overarching rad control decisions for operations seem to be made by rad engineers or senior health physics types (rather than rad techs or their supervisors): at DOE and Health Physics Society conferences one sees speaker after speaker get up and describe the conduct of an operation in which this is the case. While it is not always the case that the rad tech organization and the rad engineering/professional health physicist organization are separate, the functions generally are.

One reason that I think that DOE "talks the talk" but does not "walk the walk" is that at these conferences and elsewhere, we would hear DOE announce this or that grand plan for improvements in safety requirements. Then in subsequent months and years, DOE would delay, soften, or cancel the plan. They

would invoke budgetary restrictions or new "practical" considerations for their having thought better of it. But usually it would be clear that after they received contractor feedback or after a new Secretary took over DOE, they made a political decision to change. In recent years, they have been their own worst "bashers", saying of themselves things like "We were too given to "one-size-fits-all" regulation" or "We realized that the workers knew best how to organize the work" -- i.e., the sort of statement that makes them look as if they did not know what they were doing all along. These statements are in the form of self-criticism, but they come across as self-congratulation after enlightenment.

An early example of all this for me was the 1991 DOE Rad Protection Conference. DOE organized it for DOE personnel and contractors to hash out issues arising from 5480.11 and the upcoming DOE Rad Con Manual. (Note that my quotations in this book of what people said at this and other conferences come mostly from my copious notes, not from handouts. I hope that if I misquote anyone, someone will send me a correction.) A DOE speaker at this conference stated that DOE was going to issue "implementation guides", which would help the contractors figure out how to implement new and existing rules. In particular, the "elements of a minimally acceptable rad control program" would be defined so that there would be less subjectivity in DOE oversight. There would also be technical manuals and other substantive written help provided.

One contractor speaker who was on some sort of DOE safety advisory committee said that the breakup of the Atomic Energy Commission into NRC and ERDA (which later became DOE) had resulted in a loss of oversight. NRC and the private Institute of Nuclear Power Operations (INPO) had produced a culture change in the NRC world -- and a corresponding change in the way health physics was regarded there -- but there had been no corresponding change in the DOE world. With the rapid defense buildup in DOE, production was favored over safety. In particular, he added, the integral application of health physics was carved up into "work packages"; health physics was driven "down the chain" and professionalism downplayed. There had been an overall decline in DOE rad protection in the 70's and 80's, but it was on the way back (with the new DOE initiatives). Contractor safety management problems resulted in DOE's having technical safety appraisals, committees such as his, and "Tiger Teams" (peer assessment teams).

Regarding self-assessment, the speaker said that DOE guidance stated that "line managers are responsible for safety". There was "not much happening in self-assessment offices" because there were too many layers of management over them and not enough health physicists to staff the job and do it professionally. Notably, he quipped that "independent self-assessment is an oxymoron the way DOE is carrying it out". DOE was turning to an inspection mentality culture, not one based on guidance, as it used to be. In this, DOE could not do the job as well as NRC (due to their respective make-ups, cultures, etc.). He thought that DOE was right to emphasize ALARA but was speaking of it mainly in terms of dose reduction, rather than of dose optimization and dose management. He didn't doubt that DOE sites had the best health physicists in the world, but he stressed that with their organizational and management structures, the top health physicists became managers in offices and were not sufficiently involved down into the line. For the optimal use of facilities, especially old ones, one needed professionals to make the judgments.

A Hanford contractor speaker said of a waste vitrification plant design project that Operations' definition of ALARA was "Be reasonable -- do it my way!" But he went on to describe how the optimized shielding thicknesses were successfully arrived at in the project, i.e., how the operations and rad safety people worked out their differences. A Los Alamos contractor speaker described the struggles the ES&H organization had had at his site to implement 5480.11: line management felt that it wasn't science, was a drain on resources, wasn't budgeted for the year, and was an ES&H responsibility anyway. Further, Los Alamos line management was weary of DOE's regulatory zigs and zags and the "bring me a rock game". So they wanted to "wait until the dust settled" and see what DOE's real position was. The ES&H organization therefore had a lot of trouble writing the DOE-required implementation plan, especially since they could not estimate the costs to be borne by line management without line management's input.

During the question period following this talk, a DOE person agreed with a Brookhaven person's suspicion that the (local) DOE program offices were sitting on the implementation plans submitted by the contractors and that was why the contractors were having to wait a long time for DOE-EH-Washington to approve them. He implied that the reason was funding-related, saying that this was "a game with many players" (budget-wise) and DOE-EH-Washington was only one.

(I will digress here to explain the expression "bring me a rock", as it is shorthand for a situation that seemed to arise frequently in the DOE world. Setaro expressed it to me as follows. Your boss, or DOE, or whoever gives you orders tells you to go out and bring him a rock. You go out, find one, and bring it to him. He looks at it and says, "I don't like that rock. Bring me another one". You find a different one and bring it back. He doesn't like that one either and tells you to get another. Etc., etc. The point is that he never tells you what kind of rock he has in mind, never specifies what he wants, so you are on an endless quest. The reader may ask why he doesn't tell you what he wants. The implication, for some bosses, is that they are, as the British say, "bloody-minded" and like to play with people. The implication for other bosses, including DOE, is that they don't know themselves what kind of rock they want, but they'll "know it when they see it".)

A Westinghouse Hanford speaker gave the results of a pilot project for "job-specific" RWPs. His talk handout stated that "all job-specific RWPs are required to have an ALARA review" and that the work package was "sent through a series of steps [which were detailed in the handout] to identify ALARA levels and requirements". The reason for going to this system was DOE, technical safety appraisals, a Tiger Team, and self-assessment findings; the Tiger Team in particular observed that "management has not assured the performance of job ALARA reviews" and that Westinghouse Hanford had not established "radiological action levels [trigger levels] to require escalation of the ALARA review process". The Team also noted that tracking and trending of RWP data was not being done. The handout stated that then-DOE Secretary James Watkins wanted DOE facilities to meet nuclear industry standards and it showed that the Westinghouse Hanford rad protection organization did a dose estimate as a routine step.

Regarding the comments by the speakers above, I note the following. The implementation guides were issued by DOE eventually -- but for 10 CFR 835. They also issued technical manuals. But as I will explain later, these do not seem to have been applied at ORNL nor did the DOE oversight people ever seem to invoke them in their reviews of ORNL. Thus as we will see, while DOE made and announced many grand plans, these plans did not appear in a timely manner and when they did appear, they could be ignored, even as guidance. The comments of the speaker from the DOE safety committee are significant in light of what later occurred at ORNL; they should also be recognized as being consistent with what DOE's expert consultants (such as that committee) were telling DOE, in particular the comments on the DOE-world limitations of self-assessment and the (mis-)interpretation of ALARA as just dose reduction. The Los Alamos speaker's comments illustrated the downside of not having line management buy-in on regulation implementation and the problems of the safety people's not having the authority to require line management input on a matter that materially affected rad work. The Hanford people were taking the work control process to a new level (which they became well known for in later years) and were applying the less common techniques required by DOE, such as optimization; note that the things that the Tiger Team had criticized them for -- and they had started to do -- were not being done formally at ORNL.

#### The 1992 DOE Rad Con Manual -- Background

Partly in response to criticism by Congress regarding DOE's lack of safety rigor (e.g., as compared to the nuclear power industry and the Navy nuclear program) and partly in response to recommendations by the Defense Nuclear Facilities Safety Board (an oversight entity created by Congress), DOE issued the original version of the DOE Radiological Control Manual (RCM) in June 1992 as DOE/EH-0256T (with "DOE N 5480.6" for the notice announcing it). Although DOE was the nominal author, it was reportedly written in what appeared to be some haste by some old military buddies of Secretary Watkins. True to its

military-oriented origins, it was called the Radiological Control Manual, not the Rad Protection Manual or Rad Safety Manual, and was divided into "articles" rather than sections or chapters.

The principal objection the contractors had to the RCM was what they viewed as its "one size fits all" nature. They opposed the way that it removed flexibility from how they handled operations. But they also resented the fact that few contractors had seen it before the draft went out for what was seen as a pro forma all-sites comment period. It was known that an earlier effort at an RCM by DOE and contractor personnel was rejected out of hand. (According to ORP section head Ron Mlekodaj, who was one of the people who worked on it, there were some hard feelings about the rejection since DOE had asked sites to donate time and personnel for this.) Also, I was told by a DOE-Washington ES&H manager at a later conference that the DOE rad protection staff had counseled Secretary Watkins against putting out the RCM so soon -- they advised a longer comment period on the draft than he had authorized. The staff felt that they would get better buy-in by the contractors and produce a more universally workable document if they allowed more time for the bugs to be worked out. But Watkins refused.

Although the manual was directed at operational entities as much as at rad protection organizations -- with whole paragraphs delineating responsibilities of operational management -- the formal response to DOE came mainly from the rad protection organizations and the implementation effort was mainly their responsibility. So the rad protection organizations were put into the position of defending the operational interests before DOE. Most did not seem to mind: in national DOE and professional meetings during this period, most of the contractor rad protection people I talked to expressed misgivings about the RCM.

I myself voiced strong objections to the RCM, in written comments to my management that I assume were included in those they sent to DOE. I shook my head over many of the RCM statements on safety approach and policy, which I viewed as being the sort of empty verbiage that sounded substantive but actually meant nothing in terms of guidance or implied action. I thought that even many of the technical provisions were insufficiently clear and focussed on the means rather than on the ends. And I believed that DOE was deluding itself and Congress if it really thought that the RCM would make a difference in the short term in safety culture. All in all, as Setaro remarked, one had to oppose "change for the sake of change". The RCM seemed to require major and expensive changes for a dubious improvement in safety.

Today, however, I hold a different opinion of the RCM's potential effectiveness. I still think that DOE could have done a much better job of writing and editing it and I still think that DOE could have had better implementation of it if contractors had been more involved in preparing and presenting it to other contractors. But as time went on and ORNL and the rest of the DOE sites implemented it, I saw that in many important areas, the RCM provided a common set of numerical values and ways to proceed, especially in contamination control. Further, the RCM did have a method by which contractors could request exceptions to particular provisions by proposing alternatives; some sites did in fact ask for and receive permission to use such alternatives. Finally, I took it for granted at first that the contractors made their cost estimates in good faith, but later I realized that the estimates of how much it would cost to change were inflated, as DOE probably realized from the start.

#### The 1992 DOE-ORO Rad Protection Meeting (Oak Ridge, Tennessee, 5-6 May 1992)

Many objections to the RCM were made during the May 1992 DOE-ORO rad protection meeting. The RCM was to go into effect in June 1992, so contractor interest was high. The MMES (central) rad protection manager, Glenn Murphy, asserted that nearly all sections of the RCM had technical inaccuracies and that some were inconsistent with DOE Orders and the proposed 10 CFR 835. Further, he said that the RCM was suitable for a small, well-controlled operation, like a submarine, but not for a large multi-facility site. His office had sent 74 pages of comments from Y-12 and K-25, while ORNL had sent 26 pages. A local DOE-ORO (Oak Ridge) official said that DOE-Washington was not aware of the cost and time it would take to implement the RCM nationwide. He claimed that it was "conceivable that the

implementation, training, etc., could cost as much as \$500,000,000 and [take] four to five years". (The memo that the DOE-ORO site head wrote transmitting the contractor comments to DOE-Washington said \$500M-\$800M, with recurring costs of \$50M-\$80M annually. It claimed that these costs could be doubled if certain requirements "are literally interpreted".) Jerry Hunt, head of rad protection at the Y-12 site in Oak Ridge, said that most of the area impact would be at the Y-12 facility and would be the result of having to reconfigure and repost the Radiological Controlled Area(s). It was pointed out that the RCM was required only via the contract the site contractor had with DOE, so that if DOE did not also give the contractor extra money for implementation, the contractor was not required to adopt the RCM.

I asked what the purpose of the RCM was and why DOE thought it was necessary. A local DOE-ORO official's response was that it was a recommendation of the Defense Nuclear Facilities Safety Board review at the Savannah River Plant and at Rocky Flats; the idea was that if these two DOE sites had a "less than exemplary" rad protection program, all DOE sites' programs likely needed upgrading as well. ORNL's Mlekodaj commented that Secretary Watkins' original memo said that the reason for the RCM was the daily reports on contamination and incidents that came across his desk; Mlekodaj asserted that if the RCM were implemented the reports would still come because of the number of people working and because "it is just the nature of the job". Mark Robinson of DOE-ORO thought that instead of the RCM, guidance (e.g., job review method handouts) would be useful for "ALARA [to] develop as a real tool for contractors to decide what is reasonable".

Various comments at this meeting seem nonsensical in hindsight. Someone said that Brookhaven (not represented at this regional meeting) was upset because their research might be "put out of business completely" by the RCM. An example supposedly given by the Brookhaven people was that if a researcher were using radioactive material on a table, "you would have to post all around the table" and that "by the time you cover the table and surrounding area with postings, you will not have enough room to perform the work". Thus if every one of the individual small research areas at Brookhaven had to be posted, "they are not going to be able to work". (But the reader should note that, as I later saw at the University of Tennessee, universities and other places doing benchtop research manage to demarcate and post or tape-mark off the rad areas under NRC regulations, without running out of space.) Hunt asserted that "If you go in and issue new postings stating that areas are hazardous that were not hazardous last week, this will surely cause panic and fear....It may cause a lot of workers to start [law]suits because of the increased fear and the change in postings and responses to minor incidents". (We saw no such subsequent reaction. Workers recognized that all of the posting was DOE-mandated and took it in stride.) A DOE-ORO official said that at a previous meeting, DOE stated that "There are no health benefits from the implementation of this manual; it will be compliance for compliance's sake only". (I was at that other meeting; I think that was not what the DOE speaker he quoted actually meant.) Murphy claimed that implementation of the RCM "absolutely gains nothing -- we are going backwards". There were also various statements that the RCM said things that, when one looked in the RCM, one could not find. (But these statements could have been misquoted by the writer of the meeting minutes -- as one of mine was.)

It was stated that Hanford and Rocky Flats had looked good recently because they had a formalized approach to implementing ALARA and "seemed to have a better handle on their program", the idea being that the Oak Ridge area sites could better learn from them than from the RCM. Kurt Geber commented that ORNL's Rad Engineering Group (i.e., Geber and Rich Utrera, under Butler) was not very involved in design reviews "because we are not called to be procedurally"; as far as interacting with the ALARA group (i.e., Setaro, Gheesling, and me) on design, "we either have to stop what we are doing now and dedicate ourselves to doing that or get more manpower". A K-25 person remarked that the Rad Engineering Group there had had a similar problem, but then they began to do design and other reviews together. Steve Trotter of Y-12 said that at Y-12 comments were reviewed and recommendations written by a rad engineer; the recommendations were reviewed by a peer reviewer and the comments went back

to Engineering; also, Engineering had a procedure identifying key review personnel (thus ensuring rad/ALARA engineer inclusion).

A vote was taken at this meeting on the RCM: 22 people voted to advise cancelling it, 28 to implement it with changes, and 1 to implement it as was. It was clear that there was a lot of sentiment against the RCM and that it was being crammed down the contractors' throats. But as I stated earlier, eventually a lot of these charges against the RCM turned out to be dubious or overstated, particularly the implementation cost estimates.

I must emphasize that what I report of this and other DOE-contractor meetings represents just the points of interest with respect to the themes of this book. I have pages and pages of technical notes on surface contamination, air monitoring, dosimetry, etc., which actually formed the bulk of the meeting. Because of our technical dedication, grouching about requirements formed only a part of these time-consuming but worthwhile meetings; most of the time was spent in sharing approaches to solving technical problems.

#### The Radiological Control Manual (RCM) -- Content and Implications for ORNL

The main provisions of the RCM -- the official word from DOE on the subject of operational rad protection -- are summarized below. The citations below should be compared to DOE's actions as I describe them below and later. I have added some comments regarding ORNL implementation.

DOE's rad protection policy was restated, including the ALARA dictum that "There should not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure". (As I stated earlier, anti-ALARA folks believe that doses up to regulatory limits produce no harm; consequently they are against making what they regard as useless expenditures of effort and money to reduce doses below these limits. Hence they view the idea that there needs to be a benefit from even the smallest doses as nonsense. Again, I am not taking a position on this one way or the other in this book -- I am explaining what DOE's and the contractors' safety position was at the time.) This dictum was a "key element" of President Reagan's 1987 guidance to Federal agencies and DOE was "firmly committed" to having "a Radiological Control Program of the highest quality".

In the part titled "Leadership in Radiological Control", it was stressed that "consistent review and informed interest by senior [site] management" was necessary to produce a superior rad control program and that "what management does speaks louder than what management says". Ways were listed in which senior management should show commitment, including holding workers and supervisors accountable for radiological control performance. Other key provisions were that management should "foster the mindset" that contamination prevention was cheaper than cleanup, that goals should be established that were "measurable, realistic, auditable, and challenging", and that "Line management should be held accountable for implementation of the Rad Control Program" (the underlining here and below is mine).

Article 125 emphasized that the concepts of DOE Order 5480.19, "Conduct of Operations", should be applied to the conduct of rad control and stated that "Assurance of adequate radiological safety should not be compromised to achieve production, remediation, or research objectives". Article 127 required that a formal critique process be established for fact-finding after an "unusual radiological situation" or "satisfactory conclusion of a new or unusual operation". Article 352 required that the site-specific RCM include requirements for postjob reviews. Article 353 stated that the rad control organization, "in conjunction with line management", should distribute lessons learned and incorporate them into training.

Article 128 (on radiological design and modifications) gave specific design limits (e.g., 500 mrem/yr to an individual worker) and required that doses be ALARA. The requirements of DOE Order 5400.5, "Radiation Protection of the Public and the Environment", were to be applied (which was superfluous since 5400.5 already applied). A quality factor of 20 for neutrons was to be applied in design -- in case the

authoritative international body that was considering 20 instead of the accepted 10 were to adopt 20 in the future. This provision was stupid from a technical point of view and was eventually changed after what appeared to be a nationwide chorus of objections from health physicists, including me; e.g., this would have had a big financial impact on the design of the shielding for the Advanced Neutron Source. In Article 137, on neutron exposures, similarly dubious statements were made about how neutron effects were less well understood than gamma effects, as a justification for exerting more control over neutron dose than beta-gamma dose even after applying the quality factor. Article 131 gave specific examples of radiological goals, such as for collective exposure, number of skin contaminations, and number of curies released as airbornes. It was emphasized that the point of goals is to measure and motivate improvement, not to be an end in themselves. All the goals given seemed to be sound radiological metrics, not soft, touchy-feely indicators. There was a requirement for an ALARA Committee.

Article 141 contained the startling but probably pro forma requirement that a Radiological Control Organization be established. I say "startling" since having a rad protection program was already a requirement at all sites and they all had a rad protection organization already, at least as part of an ES&H organization. It was required that the rad control organization be "independent of the line organizational element responsible for production, operation, or research activities" and that it "should have an equivalent reporting level". Also, rad control personnel were to ("shall") "ensure adherence to the site-specific Rad Con Manual and be available to the facility line manager for radiological support to the work force". While "to effectively function in this capacity, they should receive their day-to-day priorities from facility managers", the rad control organization was to be accountable to the Rad Con Manager, not to line management, "to ensure independence in making correct radiological decisions". And the Rad Con Manager was to "have access to the senior site executive for radiological control matters". Per Article 143, the rad control organization was to include among its senior staff "health physicists and other professionals with four-year degrees in science or engineering". "Radiological support personnel" were to provide support in "health physics and radiological engineering, dosimetry, bioassay, independent oversight, instrumentation, and calibration"; they were to have "technical qualifications pertinent to their assigned duties", but there was no explanation or definition of what those qualifications should be.

Although the regulatory individual whole-body dose limit was and is 5 rem per year, Article 211 set a "DOE Administrative Control Level" of 2 rem per year. Approval by a high-ranking DOE-Washington bureaucrat would be required for a site to exceed this. Since such an approval would take weeks if not months, short of an acute emergency, the RCM thus set a de facto individual limit of 2 rem per year. Besides that, each site was required to set a site Administrative Control Level below the 2 rem, with the permission of the "senior site executive" (e.g., the ORNL director) being necessary to go above this level. A choice of 500 mrem per year was suggested, with the statement made that 1500 mrem was "in most cases not sufficiently challenging to meet the goals of this Manual". (ORNL chose 1500 mrem.)

The RCM devoted a lot of attention to airborne and surface contamination control, with various articles covering these topics. In particular, the various types of control areas (such as Contamination Areas and Radiation Areas) were defined and the ways they should be posted were specified. This caused a lot of heartburn among the contractors because some of them had idiosyncratic definitions and posting methods.

The series of articles beginning with Article 311 became the battleground on which many ORNL internal rad protection organization clashes occurred because it dealt with the most important area where the operational rubber meets the radiological road: rad work. In Part 1 ("Planning Radiological Work") of Chapter 3 ("Conduct of Radiological Work"), Article 311 stated that "Technical requirements for the conduct of work, including construction, modifications, operations, maintenance, and decommissioning, shall incorporate radiological criteria to ensure safety and maintain radiation exposures ALARA...[so] design and planning processes should incorporate radiological considerations in the early planning stages". As I described earlier, Y-12 had done this by providing for review of design work and operational

procedures by its rad engineers. Independently, it seemed to us in the ORNL ALARA Program that we were the logical "shop" in which this should be done at ORNL. (In the eventual overhaul of the health physics procedures to conform to the RCM, the duties of Article 311 would in fact be assigned to the ALARA Engineering Group, the group that evolved from the ALARA Program.)

Article 312 continued in this vein: "Maintenance and modification plans and procedures shall be reviewed to identify and incorporate radiological requirements, such as engineering controls and dose and contamination reduction considerations". It said that performance of this review was the responsibility of line management (i.e., ensuring that the review was done), and that the review required the "support and concurrence" of the rad control organization. A sensible concession was made that for routine tasks, tours, and minor nonradiological maintenance, the review and its documentation could be done as part of the RWP process -- i.e., the information-gathering and thought processes that produced the RWP constituted the review and the RWP would thus constitute the documentation of the review. But for nonroutine or complex work activities, the site RCM was to ("shall") establish trigger levels for formal review, including dose, dose rate, and contamination triggers. Tasks with a potential to exceed the triggers were to ("shall") undergo a formal, documented radiological or ALARA review, considering at a minimum:

- Putting rad control hold points in the technical work documents
- Using work processes and special tooling
- Using engineered controls
- Specifying special radiological training or monitoring requirements
- Doing engineering design for and using temporary shielding
- Doing a walkdown of the activity using applicable procedures
- Reviewing abnormal [contingency] and emergency procedures and plans
- Developing a prejob estimate of collective exposure to be incurred

Radiological requirements identified as part of this review were to be documented in the job plans, procedures, or work packages. Review by "the ALARA Committee" was to take place if site-specific criteria were exceeded. Finally, it was stated that "optimization techniques, including cost-benefit analysis, represent a fundamental part of radiological design analysis and work review". A sensible statement was made that "for review of minor activities with low associated doses, a cost-benefit evaluation is an intrinsic part of the engineering review process and a detailed evaluation is not necessary", but a "detailed and documented" evaluation was to be performed for tasks with higher doses.

Article 313 focussed on infrequent or first-time activities. It required formal rad review, senior management review, ALARA Committee review and approval, and "enhanced line and rad control management oversight" for such work.

Articles 312 and 313 together thus laid the foundation for a structured and formal review process for work. At ORNL this was at first the province of the ALARA Engineering Group (AEG) -- on paper. As I will discuss later, many of the items above that were supposed to be considered during a review were not, due either to the assignment of them to the rad tech organization or to the failure of line management or the rad techs to bring a design task or operation to the attention of AEG, who otherwise had no way of finding out about it. (The reader is reminded that when AEG was formed, rad engineers Geber and Utrera moved from the rad tech organization into this group, to join Gheesling and Westbrook under Mei. Thus it would in fact be the rad tech organization that was the funnel to rad engineering review.)

Article 314 said that the use of temporary shielding was to be controlled by procedure, but at ORNL this was not done. That is, although an ORNL procedure mentioned temporary shielding, responsibility for requiring and using it was given entirely to the rad tech organization and the conformation and thickness of shielding was left entirely to their discretion, on a case-by-case basis. Once the professional health

physicists in the rad tech organization who were conversant with shielding issues had retired, that organization relied on neutron, gamma, and beta lookup tables or the gamma-specific Microshield program for nearly all shielding determinations (which meant that, e.g., scattering off side surfaces would not be considered), or else they accepted the calculations done by the O&R people. AEG typically had nothing to say about such calculations -- were not required to review, check, or even look them over -- despite the fact that Mei and all four of her rad engineers, especially I, had had formal, advanced training in shielding while few if any of the rad techs did. Readers who are not rad protection specialists should be aware that doing advanced shielding calculations is not "rocket science" but can be close to it. Many evaluations needed for temporary shielding would not require advanced calculations, but a person with limited knowledge of shielding would not necessarily be able to determine what level was appropriate.

Article 315 was on technical work documents ("procedures, work packages, or job or research plans"), which were supposed to be used to control hands-on work with radioactive materials. These documents were to be reviewed and approved by the rad control organization. There was an exception: routine work activities for which there was a low potential for worker exposure or workplace contamination, e.g., trash collection, did not require a technical work document. This article was anathema to those who were allergic to having to make written commitments to doing work a certain way, instead of making it up as they went along. In putting in this article, DOE recognized that it was important to have people plan in advance what they were going to do and document it so that everybody involved knew what was to transpire. Once a document had been written for one activity, it could of course be reused for the same activity or revised for similar or related activities. So there was no need to start from scratch for each task.

The lack of documentation of work was one of the main things I faulted some ORNL line management groups for. Usually there was supposed to be a procedure for an operation or task, but it would be in draft form until the end of the day before work was to start. Often the rad engineer would not be asked to read and comment on it before then, if at all; even the rad tech organization did not always get to review these procedures and certainly did not get to approve them in any real sense. Such procedures often lacked the sort of radiological control statements that were envisioned by the authors of the RCM. There might be hold points, but frequently they were arbitrarily set on the basis of what sounded good and they did not allow for flexibility. More than once it happened that in the middle of work a control or an administrative dose limit would be deemed impractical and the line supervisor and the rad tech would agree, in the field and on the spot, to a deviation. The procedure would be lined through and reworted and the change would be initialed, usually by just the line supervisor. Sometimes even that formality was dispensed with. This sort of thing in effect threw review and approval by anyone else out the window.

Article 316 was on respiratory protection. Using a respirator for an extended period can be hard on a person, especially when he is wearing layers of protective clothing -- it can contribute to respiratory distress of various kinds, to heat stress, and even to heart attack. Hearing alarms and oral communications and seeing through the face mask are also more difficult. Using a respirator can increase the time taken for work because of the inhibition of movement and communication. As everybody in the nuclear industry recognizes, respirators have their place in rad work, but should be used sparingly. That is why DOE, in its design and control directives, required that engineered controls (such as air filters and gloveboxes) be used instead of respirators, to the extent practical. Article 316 specifically dealt with cases where using a respirator might be contraindicated. This included the case in which, with the respirator slowing down work, the extra time taken would result in extra external dose; if this extra external dose exceeded the internal (inhalation) dose that would be received without the respirator, then it would be more dose-minimizing overall to work without a respirator than with it. For this situation, Article 316 said, written authorization from the line manager and the Rad Control Manager had to be obtained before respirators could be omitted; also, justification for it (i.e., a dose estimate) had to be provided in writing.

This is definitely an ALARA area. Yet at ORNL we AEG rad engineers seldom (actually, probably never) got to give advice on, much less require, the use or nonuse of respirators -- this was always a rad tech or line management decision. As far as I could find out, there was no technical basis or guidance document to help the rad tech organization decide when to use respirators. Often, the line organization seemed to be the only ones to decide on respirator use, i.e., even the industrial hygienist might not be consulted. Thus the use/not use decision was a subjective judgment, albeit one guided by the experience of the rad techs and line management. I believe that the permissions that the RCM called for were seldom or never sought, and I never saw a copy of any written justification or estimate. That said, I also note that at ORNL, anybody who wanted to use a respirator was usually allowed to do so, whether it was really justified or not. This was a concession to the craftspeople and their union, since they were most often the ones doing work in which respirators might be needed. A union representative, a millwright, once told me that he didn't care if the extra external dose was estimated to exceed the internal dose: if there were any airbornes at all, he wanted a respirator. The craftspeople's attitude was that external dose was understood and relatively acceptable, because you could see it measured in real time on a pencil dosimeter, but not internal dose, because you couldn't tell in real time how much you were getting.

Article 321 was on RWPs. It had a long list of items to be included in an RWP. Besides the usual -- work area, dose rates, contamination levels, required protective clothing, and dosimeters -- there were also to be included limiting radiological conditions that would void the RWP and any special instructions about frisking or dose or contamination reduction. There was an exception, for flexibility: "an alternative formal mechanism", e.g., a written procedure or experiment authorization, could be used if it met the same requirements as an RWP. The biggest RCM change was that workers were to read the RWP and sign it to acknowledge that they had "read, understood, and would comply with" it. This was the norm in nuclear power plants, but was new to some DOE sites.

Article 324 said that prejob briefings were to be held prior to any work in which the Article 312 trigger levels might be exceeded. Those attending were to include workers and supervisors directly participating in the job, "cognizant" rad control personnel, and "representatives from involved support organizations". We in AEG believed that this included us if we had participated in planning a job, especially if the job would hit the trigger levels and we had signed the RWP. We often found out when the prejob briefing would be held only if we attended a meeting at which it was mentioned, or if some conscientious soul on the project told us. Some line groups would "forget" to tell us. But others considered our attendance important since they believed that the briefing, while mainly for the benefit of the workers, should be inclusive because it was a last chance for any miscommunications or overlooked details to come to light.

Article 325 and other articles dealt with protective clothing or "PCs", including launderable and disposable coverall-type clothing, hoods, booties, and gloves. I won't give details of the requirements here, but this was one of the most controversial issues in the RCM. The main reason was that in general, the more layers of PCs, the less likely is a skin contamination through the material. But as noted above regarding respirators, extra clothing can be detrimental to health and safety and also to efficient work because it increases the possibility of heat stress and makes it more difficult to move and to keep track of position. Contractors supporting work in, say, the hot Nevada desert were very likely to oppose any rigid requirements for numbers of layers -- rightly so, in my opinion. But in fairness, I must add that while DOE did have some rigid "shall" requirements for PCs, they also said that the use of personal protective clothing and devices beyond that authorized by the site rad control organization "detracts from work performance and is contrary to ALARA principles and waste minimization practices".

Article 342, on "work conduct and practices", had various statements about radiological controls like this: "engineering controls, such as containment devices, portable or auxiliary ventilation, and temporary shielding, should be installed in accordance with the technical work documents and inspected prior to use". At many sites, containment devices and portable ventilation have to be approved (or "certified") by

rad engineers or senior health physicists under a formal process. But ORNL had no formal process for the rad protection organization to verify the adequacy of the type, operability, or installation of airborne control devices -- there was essentially just an informal okay on the part of the tech or his supervisor and approval was provided by issuing the RWP. The ORNL procedure that included Article 342 requirements was always "owned" by the rad tech section and during procedure revisions, AEG comments on it were ignored. Shielding and ventilation approval by AEG was one area I was vocal about virtually until the day I left ORNL -- I and also Geber raised this question repeatedly with Mei and Mlekodaj, but to no avail.

Article 345 dealt with stop-work authority: "any worker" had it "through their [sic] supervisor". The reasons that a rad tech, his supervisor, line supervisor, or any worker would stop work were given as "inadequate radiological controls, radiological controls not being implemented, and radiological control hold point not being satisfied". Work was not to resume until the line manager and the rad control manager both approved it. Since the latter might have to be tracked down and briefed before work could resume, at ORNL (as at other sites) the procedure read "rad con manager or his designate", so that approval could be obtained reasonably quickly.

Article 453 dealt with control of airborne radioactivity. This required that processes and activities with the potential for producing airborne radioactivity include "engineering controls to limit releases"; that the rad control organization be notified when engineering controls such as (air) barriers, gloveboxes, and glovebags were compromised; that an evaluation be made of continuing to operate with compromised controls; and that preventative maintenance and surveillance procedures be established to ensure that controls were kept in operable condition. Again, this sounds like a job for rad engineering -- and it is at most sites. At Hanford, for example, engineered controls have to be certified by authorized members of the rad protection organization. But at ORNL, except for a glovebox review upon initiation of use or modification, all of these controls were typically implemented with only line management and rad tech involvement.

Article 551, on radiological monitoring and surveys, said that the rad control organization "shall perform and document a review of the adequacy of sampling and monitoring systems as part of any facility or operational changes affecting radiological control"; that "in the absence of any such changes, a review should be conducted annually"; and that "monitoring data in each building or area should be compiled and reviewed at least quarterly". Also, "monitoring results should be made available to line management and used in support of pre- and post-job evaluations, ALARA preplanning, contamination control, and management of radiological control operations". I never saw any such review of the adequacy of these systems performed by ORP. In about 1994 ORP's Don Gregory was put in charge of monitor issues for ORP and became chairman of the Health Physics Instrument Committee. I don't recall any substantive contacts between Gregory and AEG on the subject except for once or twice when I asked him for information. This may have been a very compartmentalized function within ORP and AEG thus might not have seen any review. However, we should have been shown monitoring results when we performed job evaluations, ALARA planning, etc. But normally I had to ask the rad techs for these results if I wanted to see them. I would very often get an oral response to the effect that the monitor was "reading nothing"; I was seldom shown anything in writing. The rad techs, custodians of this data, often seemed to regard airbornes as not significant if there wasn't enough to set off a monitor alarm and some of them did not see the point of trending the data over time. So they might not know if the activity on the monitor was a truly gradual accumulation or was the result of several "puff" releases. Some complex leaders did seem to review the data conscientiously and try to investigate discrepancies, but others did not.

I had pointed out in a Reactor Operations Review Committee meeting that with only one or two CAMs in each operating corridor at HFIR, it was important to put them in the most appropriate location for leakage detection. This did not seem to have been done in the past. The rad tech organization had total say about the placement of the CAMs, but they seemed to defer to the reactor division (RRD). So CAMs were

frequently put in locations where they would not interfere with operations -- and thus were not optimally placed. When the RRD people wanted to move a CAM in one particular instance, the rad tech complex leader agreed. It was unusual for the rad techs to consult me about any issue regarding air monitoring, but one of them gave me a map showing the new and old locations (I assume on the orders of the complex leader). I questioned the move but was immediately given to understand that this was the way it was to be. They had given me the map as a courtesy, not because anybody really wanted my opinion. This was frustrating since from my 13 years in power plant design, I had experience in determining monitor placement and, especially, ventilation flow. I was never informed about any HFIR CAM issue again.

Article 553 said that "the need [for] and placement of area radiation monitors should be documented and assessed when changes to facilities, systems, or equipment occur". It was notable that at ORNL, many area radiation monitors, like the CAMs, were not optimally placed. Nearly all of them had the same (numerical) alarm settings, for which there appeared to be no technical basis. I will have occasion to describe the implications of this in a later chapter, but the rad protection specialist reader will no doubt already have been startled by the thought of several dozen or more area radiation monitors all having the same setpoints regardless of isotope, distance from the worker position, and type of operation or facility. The reader should also recall that the Tiger Team assessment I described earlier also observed this.

Articles 612-614 required the use of standardized DOE "core course" materials for rad worker training and rad tech training; site-specific information was to be added. Article 615 required that rad techs and rad tech supervisors pass an oral examination by a board that included at least one rad tech supervisor, another member of the rad control staff, and a line management supervisor. Having a core curriculum meant that rad workers could travel from site to site and take only site-specific add-on training, thus saving time. But most people, including me, thought that the oral board requirement for rad techs was overkill. I also thought it inappropriate to have line management represented on the board; this may have been part of DOE's effort to get line management buy-in on safety, but it also allowed line management some say in whether safety people were qualified or not. If the line rep asked a question that the examinee could not answer, a question relevant to that line management's operations but not to the general qualifications of the examinee, would he still be marked down for missing it, as a courtesy to the line rep? Even if the examinee passed, would his score be unrepresentatively lower than it should have been? If the line rep did not come up with his own questions but asked questions prepared by others on the board, then was his presence really necessary or worthwhile? I felt that DOE had not really thought this through.

Articles 641-645 also dealt with rad tech and tech supervisor training requirements. Required standards included "Systems and fundamentals of process, operations, and maintenance". It was not clear how detailed these were supposed to be, but the ORNL training I saw over the years was very superficial in this area, due to the great variations in these details across the lab. This requirement was not practical on a Lab-wide basis because the work was so variable; ORNL thus chose to have more at-the-facility training, although usually of an informal and undocumented nature. The rad techs and supervisors were required to have a two-year cycle of continuing training, with each requalification ending with a written exam and another oral board appearance. Again, this seemed overkill to many people, including me -- once a rad tech had initially qualified, continuing education was useful, but the extensive biannual retraining and board retesting seemed to be more a luxury than a wise use of resources. The most useful continuing education, I thought, was the lessons learned module, based on experience at ORNL and other sites.

Article 651 required that line managers "who manage, supervise, or provide oversight of Radiological Control Programs...be trained in the principles of this manual". Other sites and DOE seemed to take this to mean that all line managers involved with radiologically significant work should be trained in what the RCM said. So at those other sites, the line managers had taken RCM training and DOE had even issued a set of course materials for this. Some of the other sites' courses were rather rudimentary and DOE's course went off on a loopy tangent on how to manage people (not per se the subject of the RCM). But at least

they tried. At ORNL, there were presentations at the Facility Managers' Forum meeting and explanatory handouts were prepared, but there was never to my knowledge a required course with sign-in for line managers. Setaro and I had been planning a course, but then he left the ALARA Program. Later, Mei was eager to offer such a course, even on a voluntary basis, so I put together an outline of what the course should cover. But Mlekodaj never gave us the go-ahead. The thought seemed to be that rad-savvy and educated folks like line managers would find it insulting to re-learn things they "of course" already knew and that line managers' time was too valuable, seeing that the work would be covered by rad techs anyway. I inferred from things Mlekodaj and Mei said that another problem was that if a course existed, people might be required or expected by DOE to take it, which line managers didn't want. Also -- this was one of our new ORP themes -- we were trying to keep a low profile and run interference for O&R divisions in keeping requirements to a minimum. So if we did not offer a course, this relieved line managers of having to take it. (If that makes sense.) Somehow DOE either never noticed this failure to meet an RCM requirement or they let ORNL off the hook until it was no longer a requirement.

Article 652 required training for "technical support personnel (engineers, schedulers, procedure writers)". This was the audience for the course that I prepared well before the advent of the RCM, as I mentioned earlier. Article 653 required that planners "who develop detailed work plans involving or associated with radioactivity or radioactive materials" have training "at least to the level of the rad worker training" required for those doing the work. This requirement was never implemented as such at ORNL -- nobody checked to see if those who planned the operations had rad worker training. Article 654 dealt with training of "Radiological Control Personnel" (which somehow didn't include rad techs and their supervisors). Regarding "Radiological Control technical staff and management", the requirements included education and experience commensurate with job responsibilities. What the education, experience, and responsibilities should be was not stated -- DOE left it for a guidance document.

Articles 711 and 712 stated that "The work force and management are required to use records to document radiological safety afforded to personnel onsite", including "ALARA records". What was an "ALARA record"? Potentially, it could be any record that involved tracking dose, planning operations, detecting radioactivity, etc. Again, DOE gave some information about what an ALARA record was in a later guidance document, but at the time the RCM came out, each site made its own determination. Article 723 required that records of employee rad safety concerns that had been "formally investigated and documented" be maintained. At ORNL, it was the practice for ALARA "suggestions", safety concerns, etc., to be submitted to one's supervisor or divisional rad safety officer (DRCO); it said so on the forms. Thus line people usually got to see -- and potentially squelch or influence -- such suggestions and concerns before they got to the ES&H organization. Even if they didn't, the supervisor or DRCO was tacitly supposed to be given a crack at solving the problem before it left his division. No procedure said it had to be this way, but I found this out from a line person, who seemed to think it inappropriate for the ES&H people to receive such suggestions directly. Mei began a more streamlined program of dealing with ALARA suggestions, but it was still cumbersome because there was no true formal mechanism for investigating ALARA concerns and certainly no mechanism for ORP to force a resolution of any concern.

#### The 1993 DOE-ORO Rad Protection Meeting (Oak Ridge, Tennessee, 30-31 March 1993)

This meeting was much more restrained than the previous year's meeting, due to the contractors' sense of resignation after the RCM was issued. Still, statements made by those attending all referred to the unhappiness with the RCM: the rad protection people sought basically to establish true risk criteria, eliminate overregulation, "throw away the cookbook", and "get back to professionalism" in health physics. These were all references to elimination of the RCM. "Risk criteria" meant using preset risk levels rather than regulator-set levels; often the speaker would not literally be advocating doing a risk evaluation, but rather a judgment based on experience -- informed but subjective. "Eliminate overregulation" and "Get back to professionalism" meant getting rid of set criteria or action levels -- and

making judgments based on experience. "Throw away the cookbook" meant to get rid of the RCM and similarly comprehensive and binding regulatory tools -- and make judgments based on experience.

I exaggerate somewhat in my discussion of the aims above, but the idea of using judgment based on training and experience to guide decisions and to rely as little as possible on regulatory "straightjackets" was very popular among local health physics people in those days. This idea was associated, for many people, with a desire to retain informality -- that is, to minimize the number and specificity of procedures and regulations so as to allow for maximum flexibility in decision making. It was clear that some people preferred a completely informal environment, where, while rad protection decisions were always to be made by the rad protection organization, the organization was to be completely free to choose whatever controls or measures seemed desirable at the time. In particular, "professional" was often used as a code word for using personal judgment (and not for, say, having degrees or specific kinds of training). The urge to throw off restraints seemed very strong for some participants at this meeting.

Murphy of the central MMES organization made an important point: the bulk of the extra money needed to implement the RCM was coming not as additional funding from DOE, as the contracts required, but from existing programs, often as increased overhead. This was because DOE could order that money be taken from established programs and directed to other purposes. (As I noted earlier, Setaro had told me that DOE-ORO, finding itself short in mid-year, had gotten \$1 million of ORNL program money as a giveback, resulting in a significant midyear budget hit on every ORNL group.)

Each site reported on its implementation of the RCM, in terms of percentages of RCM articles that had been fully implemented and of RCM benefits versus cost. ORNL's Gregory said that ORNL considered the RCM to be a "best practices" manual, to be implemented as resources permitted and (as suggested by the term "best practices") on a semi-optional basis. Regarding occurrence reporting, he noted that much time and money were consumed by dealing with it and he questioned the heavy use of such resources. Murphy complained of "femto-management" (i.e., even more minute meddling than micro-management). An ORNL rad tech group leader observed that while DOE-ORO said that rad protection people aren't policemen, he thought that the health physics "bully" attitude from nuclear power plants was coming to DOE. He felt sorry for "the customer" (line management) and thought that public relations should present Rad Protection as being "kinder and gentler". Someone else stated that organized labor saw compliance as the foundation of worker safety. The interesting topic of the apparent disparity between the attitudes of management and safety people on the one hand and the union on the other was not further discussed.

One speaker from DOE-Washington's nuclear safety office (NS) office surprised everybody by saying that he thought that sites' rad controls programs should be moved out of health physics (i.e., of the rad protection organization) and be put under line management direction and individual responsibility. That way, he said, health physics could just monitor and keep track and be more of an independent check on rad work. Rad workers should be so knowledgeable that they should be able to do the job safely even without Rad Protection oversight, although he added that they of course wouldn't lack it. He also said that NS wanted DOE's own line management to get more "pumped up" regarding rad control. I was surprised to hear him say that DOE-NS conducted audits of rad controls programs "to see where each site is" (I'd never seen any such audit). If NS found any line managers who were unfamiliar with the RCM or the site implementation plan, it was a sign that these managers were underinvolved in the rad protection program.

So a key theme of this conference was lamenting the "excess" regulatory pressure that the RCM represented, with the repeated note of cost. DOE again was shown as wanting to require increased rigor, but not to pay for it; DOE again had different voices giving conflicting messages. One highlight for ORNL was Mlekodaj's reporting on a stuck source incident at Building 2026: rad tech Pedro Gonzalez had immediately had the building evacuated and gotten the radiological aspects of the recovery underway. DOE-ORO had praised ORNL's handling of this incident.

The 1993 Health Physics Society Annual Meeting (Atlanta, Georgia, 12-15 July 1993)

This meeting was not sponsored by DOE, but many DOE and contractor professional rad protection people attended it. Significantly, two of the keynote speakers were management specialists who had consulted for many different kinds of companies -- i.e., HP Society officials thought that what these people had to say was of general interest to health physicists. Underlined statements below are of particular significance in the context of later events at ORNL.

One keynote speaker advocated the use of Total Quality Management (TQM) principles. She said that (management theorist) Deming's management principles were applicable to production and thus had to be adjusted if they were to be applied to service industries -- the criteria of quality, customer satisfaction, task completion, etc., were harder to measure for service work. She defined a customer as the person or entity who wants the information or product provided by the organization; she said the definition of quality was driven by customer expectation at a specific point in time. The factors for success of a service organization were that it was "customer-driven"; reflected the organization's mission; had total organizational participation, measurable benchmarks, and sufficient resources; and made continuous progress. She said she cautions CEOs not to "send people on a mission without resources" and urges them to foster collaboration, organization-wide respect for "what others bring to the table", and individual excellence. The second keynote speaker consulted for DOE and private companies. He said that work could be made more efficient ("improved") by reducing time spent by workers waiting to begin work, citing the example of "waiting for a rad man" to produce an RWP. The aim is to do "value-added work" - if the (service) work does not lead to customer satisfaction, then it does not add value.

From these and other speakers from 1992 on, it was clear where DOE, ORNL management, and ORP management got their buzzwords. As I will explain later, the idea of customer service as the highest goal for people providing safety and protective functions is problematic and is, I believe, actually pernicious to the quality of their work. One can see from the speakers' comments above that the applying TQM to "services" -- including safety functions -- means that the customer will be taken to be line management, since they are the ones who pay for the services and are the ones who presumably want the "information or product". It follows that it will be line management who will judge the "quality" of the service offered. As is clear from the second speaker's example, the qualities that line management considers to be of value -- e.g., quickness in performing a task -- will be valued over what a professional peer or a DOE auditor would consider to be of value -- e.g., judicious choice of protective clothing or shielding configuration.

From what the first speaker said, I was unsure how what she called the "strategic objectives and mission" of the organization would be defined: surely the latter would be something like "getting work done on time, within budget, and safely" for ORNL. But what would the mission be for the organization-within-an-organization that was ORP, viewed as a service organization with the other divisions as its customers? Surely it would be inappropriate for a safety organization to put as much emphasis on getting (line) work done as the O&R divisions would, since the former's emphasis should rightly be on safety. While I personally found the "continuous improvement" and "respect what others bring to the table" message of such speakers to be inspiring, I found their "customer service" mantra to be troubling. I did not realize at this time, however, the extent to which these principles were being embedded in ORNL policy.

The 1994 DOE Rad Protection Workshop (Atlanta, Georgia, 19-21 April 1994)

The purpose of this workshop was for DOE and the contractors to talk about finishing RCM implementation and beginning implementation of the forthcoming 10 CFR 835. DOE handed out the newly revised version of the RCM. Rick Jones of DOE-EH-Washington said that DOE expected full RCM compliance by 1 January 1996 and that "we'll work with you" on it. Joel Rabovsky of DOE-EH-Washington stated that 10 CFR 835 would include "basic, minimum standards", be of broad applicability, and address DOE-specific concerns. Sites were to produce a written rad protection program (RPP), which

would have to be approved by DOE and in which application of the ALARA process would be required. There would be requirements to document measures taken to achieve compliance. A records system would have to be established and maintained such that compliance with 835 and the site RPP would be demonstrated. There would be design and control requirements, including optimization and preference for engineering controls over administrative ones. Unlike NRC's 10 CFR 20, 835 would contain training requirements and surface contamination limits.

Rabovsky said that DOE Order 5480.11 would remain in force for a time, but would be revised to agree with the draft 835. DOE would continue to require use of the RCM, but not in 835. The difference between 5480.11 and 835 on the one hand and the RCM on the other was that of "basic requirements versus standards of excellence"; 835 would be required as a regulation ("law"), while 5480.11 and the RCM would continue to be required contractually. (The reader should note that the latter part of this statement turned out not to be true.) He said that DOE was advising contractors not to "overcommit", since the RPP was subject to enforcement actions; contractors should "achieve balance" to show compliance but avoid enforcement actions; and they should commit only as necessary to comply. Implementation guides would be issued, mainly technical in nature, to assist the contractors in applying 835 correctly; the beyond-strict-835 provisions would be just guidance, not mandatory. Later, Rabovsky said that rad protection people should not act as a "radiological police force".

Ben McRae of the DOE-Washington General Counsel's office explained how the Price-Anderson Act and Amendments (P-AAA) would now apply. As I understood him to say, the original Act was passed because Congress feared that if contractors and private companies were subject to unlimited financial (tort) vulnerability in case of an accident, nuclear power plants and other uses of radiation and radioactive materials would not get off the ground and companies would not take on government nuclear work. So Congress established a system by which nuclear power plant and other companies paid into a sort of insurance fund that could be drawn on by the few of them that had to pay out damages as a result of accidents. DOE contractors would thus be indemnified for their payouts. But later Congress realized that if contractors were always indemnified, there was no incentive to be safe; willful misconduct or gross negligence might occur as a result. Since the wording of the original Act made it hard to prove "willful" and "knowing" conduct, Congress amended it. McRae also addressed the question contractors always wondered about: why DOE had to promulgate "CFRs" (e.g., 10 CFR 835, with CFR meaning "Code of Federal Regulations") rather than continue to use Orders. Shifting to the Federal Gobbledygook dialect that DOE people always used when talking about this, he said that the Order system was "not designed precisely enough" to support enforcement with penalties; Orders were not promulgated through the Administrative Something-or-Other Act and exemptions to Order requirements were handled under a relatively informal system that varied with each DOE assistant secretary. He said that 835 was developed for two purposes: to provide for civil penalties under P-AAA and to take measures to protect ES&H. But 835 had a broader scope than P-AAA, in that it covered all ES&H activities and not just the strictly nuclear safety ones. A contractor suggested that P-AAA might be a blockade to contractors' efforts to achieve excellence; his answer was that 835 was an ambitious document as regards DOE's goals (which I took to mean that DOE intended 835 to be a challenge to meet, in order to motivate improvement).

McRae also talked about the upcoming 10 CFR 820 ("Procedural Rules for DOE Activity"), on how DOE was to enforce nuclear safety requirements. Any (applicable) 10 CFR could be the basis for a safety enforcement action under 820; e.g., the RPP required by 835 could be the basis for enforcement and civil penalties under 820's requirements. (This was because 820 had words that said, in effect, "You shall follow the rules that you have set for yourself and have committed to DOE to follow".) DOE could issue "compliance orders" under 820. In the NRC system, an appeal would start with an administrative law judge before going to the Commission itself, but DOE had no such administrative law system and had not yet issued appeal guidance. The meaning of "nuclear safety" as used in 820 "might differ" from the generally understood definition (which he did not state). He gave as an example a milk truck arriving at a

nuclear facility and ramming a nuclear container, causing a release of nuclear materials and resulting in personnel injury and exposure to radiation. An audience member said that this suggested that "nuclear safety" could refer to any radiation-exposure situation; McRae said that it possibly could and might be even broader than in 10 CFR 830 ("Nuclear Safety Management"), another upcoming DOE CFR.

Howard Wilchins of DOE-EH-Washington observed that "compliance" had a more positive spin than "enforcement". But, he said meaningfully, "none of you has read Appendix A" of 10 CFR 820, which he claimed constituted a radical change in the DOE enforcement program. There were positive incentives for timely "self-identification" of deficiencies and their correction; DOE felt that this would be helpful in promoting the ability "to partially or fully remediate" nuclear safety problems. DOE and the contractor had to "collectively find solutions to problems" -- DOE-EH believed in collegiality. He specified, as one of a list of suggested areas to concentrate on, the "programmatic breakdown", i.e., a situation in which a program or its execution is not proving to be effective and where incidents might result.

Ed Blackwood of DOE-EH-Washington said of DOE's new assessment policy that in verifying compliance, DOE did not want to end up "doing dumb things"; "the whole arena of Who Does What To Whom" was still in flux. DOE would be doing short-duration programmatic evaluations, with small teams covering both line and rad safety programs (apparently in holistic fashion); programmatic issues would be addressed and there would not be "long lists of deficiencies", even though it was "easier to count beans on a punch list" than to address programmatic issues. There might be a program to assist sites in trouble; DOE wanted to help contractors who were "receptive to the kind of help EH can provide"; EH wanted to "stay close to the real world [the field]". (I think the reaction of most of the audience to these statements was "Yeah, right".) While the RCM was required, it was not per se a "Price-Anderson rule". The Congress-established Defense Nuclear Facilities Safety Board had no place in DOE's assessment scheme -- DNFSB was independent and did its own thing without always coordinating with DOE. He quipped that DNFSB "can do what they want to do in terms of where they go and who they want to beat up on".

During a panel discussion, a DOE-DP-Washington panelist reiterated that the "most important thing to take back [to your sites] was this: don't overcommit, because you are vulnerable to civil and criminal penalties [under P-AAA]". He noted that the commitments would be the 10 CFR 835 requirements plus any site-specific shalls in the RPP; that "meeting milestones is dependent on resources"; and that since implementation of 835 had top priority, resources should be devoted to it on a priority basis. Another DOE panelist said that contractors should not wait until the last minute to submit their RPPs; they should also "get DOE input all along the way" and "deal in the art of the practical". He added, notably, that any RPP that depended on funds to be put into place would be rejected -- the contractor should apply for exemptions if funds were lacking. But one panelist stated that "some things are so high on the screen that DOE would rather fund them than defer them". A DOE-EH panelist said that the most sites were at the 80+% RCM compliance level and that the (nationwide) price tag for compliance was estimated to be \$240M(!), a third of it for the core training. She said that DOE counted 200 mandatory requirements in 835, but hadn't counted the non-mandatory requirements; they counted 460 shalls and 1000 shoulds in the RCM (Rev.1) and 120 shalls and some number of shoulds in 5480.11. So contractors had to "catch the train now to budget these activities" so as to meet the 1996 implementation deadline. There were changes to Article 371 of the RCM to provide relief for construction and environmental remediation activities. And one DOE person stated explicitly that an RPP plan was "the" implementation plan for 835.

One contractor said unctuously that "We at Fernald have welcomed the [RCM] and welcomed the rule [835]", but "in the wrong hands, these can be used in a very narrow-minded way" and could blind one to some very good ways to protect the worker. Also, "Article 371 is like an unfinished jewel, an uncut gem". He went on, however, to give a right-on-the-money list of construction and remediation conditions that made the usual contamination controls difficult to apply: low levels of radioactivity (making ready detection more difficult), heavy construction equipment to decontaminate, low specific activity in large

volumes or over large areas (e.g., in soil or on sidewalks), outdoor environments and adverse weather, high radon concentrations, RCRA/CERCLA (EPA) requirements to meet, rapidly changing radiological conditions, varied skill levels of the workers, and lack of permanent worker service facilities. The "world of remediation" included entry into and exit from a contamination area with four feet of snow on the ground -- and snow drifting onto the stepoff pads. This was a hard world in which to post signs that might get damaged by wind or water, in which to decontaminate expensive equipment that had to be moved from zone to zone (and which could take days for free release), and in which there were conflicts between EPA consent agreements, DOE regulations, and OSHA requirements. This was a world in which a worker should (according to OSHA) shower off asbestos contamination after having stripped off his protective clothing, while still wearing his respirator, but should (according to DOE) shower only after having taken off both clothing and respirator, lest radioactivity from the respirator get on his skin. (I.e., Catch-22.)

Another contractor spoke about problems at a Hanford area: old facilities, often with the ventilation systems inoperative; 50's-vintage electrical equipment; energized systems; and thousands of cubic yards of soil that was put into concrete basins after they had previously been used to collect radioactive liquid. Hanford is notoriously hot in summer, it has deep-rooted vegetation because of droughts, and high winds stir up contamination. Contamination is uptaken by tumbleweeds, which then dry up and blow around. Mouse carcasses reading 10-20 mrem/hr had been found in owl holes at a process building. They had to put steel plates on the floor when imploding one building, to protect the contaminated surface. The clear implication was that it would be a struggle to implement the RCM in the face of such difficulties.

In another session, Jones noted that the 835 minimum requirements were reflected in the revised DOE RCM. So since so much work went into RCM implementation, contractors should just use the RCM references to document the RPP. He stressed the importance of getting the right references (again, limited so as not to overcommit) to document the plan. Regulatory limits, such as 5 rem/year to the whole body, should be put into the RPP, but perhaps not administrative limits, or the contractor would be held to them (i.e., with the force of law): "You operate from the RPP, but the basis is still 835". There was danger in referencing an entire procedure or even part of one; the contractor should put a statement in the RPP such as "Some requirements here are of a regulatory nature" and then bold or otherwise mark the regulatory requirements. Bob Jarrett of DOE-ER said that a DOE visit to the site for enforcement purposes would involve asking only compliance questions, but a DOE visit to the site for RPP [implementation] purposes might result in any kind of question being asked. But unlike his DOE colleagues, he opined that contractors should incorporate best management practices into the RPP, not just minimal shalls from 835.

Asked if the RPP was like a [NRC] licensing agreement between regulator and contractor as to how to operate the site, Jones said that it was indeed something like that. A contractor noted that since his site's respirator use requirements were based on 1 rem, they would have to rewrite their procedures to base them on 5 rem. A DOE-EH-Washington person stated that the solution was simple: the contractor should just include a policy statement from management that the 5 rem was the limit, then say that administrative levels -- which would be unspecified in the policy -- would be set. Of DOE 835 compliance inspectors, a DOE person said that a contractor should stand up to them, that "You don't have to agree with them".

I asked Jones "Cui bono?" (whom does it benefit?). I said that I thought what would really benefit safety in a concrete way was for DOE people to spend more time in the field looking at actual jobs and activities. I had meant local (field) DOE people, but the DOE-Washington people took this personally. Dr. Maria Gavrilas-Guinn harked back to the happy sessions she had spent out in the field, including time in ORNL's HFIR reactor bay. But, she said, EH had so much to do (e.g., to give information to the Secretary and DNFSB) and now they had this RCM and 835 implementation, which was so important -- they would get back to the field later. Later, during a break, Jones, a high-level DOE-EH manager, approached me and assured me in an agitated manner that the DOE people did indeed want to get into the field. He said that DOE people like him got their orders from "them" (Congress, high DOE management,

etc.); DOE-EH technically advises "them" but "they" didn't always want to take DOE-EH's advice. He got emotional about the powerlessness of DOE people and said they wanted to do the right thing, but "There's politics!" involved that people like me were unaware of. I liked Jones and I believed he did have good intentions, but his protestations sounded like those of so many career bureaucrats, focussed more on what the higher-ups wanted than on what was best to do or what needed to be done to protect the worker.

Regarding final 835 implementation guides, various DOE people gave presentations. One said that DOE wanted to avoid "Bring me a rock" criticisms. He admitted that while the interim guides had had full DOE headquarters and field office review, contractors had not gotten to comment on them before they went out and the drafts had had hardly any review at all. The chief hangup of the contractors present was that if a guide proposed one method of meeting a requirement or structuring a program, then that might be taken by an auditor as the de facto "right" way to do it, even if the method was not required to be implemented. The DOE reps made the point that except for 835 requirements, which were firm, contractors were free to do things differently from the way recommended in the guides. But DOE was also seeking "mature, developed alternative proposals" from contractors choosing not to do things the guide-recommended way.

John Connelly of DOE-EH-Washington said that ALARA had been in the RCM draft originally, but was removed by "higher authority"; then it was put back in in bits and pieces by the contractor who wrote it. As a result, he observed, "the Secretary has changed the definition of ALARA a bit from what the NCRP says" (the National Committee on Radiation Protection and Measurements). Connelly and Bruce Dionne of Brookhaven National Laboratory put a parenthetical expression into the definition ("maintain if achieved") to cover contractors already at ALARA levels, so these contractors wouldn't have to keep reducing dose ad infinitum, contrary to actual ALARA philosophy. The assignment of responsibilities emphasized in the RCM was important because as [nuclear navy pioneer] Admiral Rickover said, "if nobody's in charge, how could you hold anyone responsible?" A dollar per man-rem figure of \$15,000 had been put into the RCM -- and then taken out for political reasons. Now each site was to develop its own number; Brookhaven's Dr. John Baum was working on a new figure for NRC (its old number for radwaste was \$1000/man-rem), a useful place to start. A Q&A on justification produced the eye-popping response from a DOE-EH-Washington that documenting justification of dose is not really necessary if the work is part of DOE's mission; i.e., if DOE authorized it, it was prejustified.

In summary, at this meeting DOE made clear to the contractors that 835 had the force of law beyond what Orders had, including imposition of civil and criminal penalties under P-AAA; 835 would also be enforceable under the provisions of 10 CFR 830; the RPP was the site implementation plan and so itself had the force of law (as a commitment by the contractor); the RPP would have to be adhered to and so should contain, beyond 835 requirements, only those shalls that the contractor could live with; clear assignment of responsibilities was important; and the assessment process was still fairly undefined. I never saw DOE-Washington people seem so human and so optimistic as they were at this meeting. Many of my good feelings about some DOE people and my (past) hopeful expectations about DOE's intentions came from this experience. Many of the local (field) DOE people seemed not to be too sharp, but these Washington folks mostly seemed to be pretty smart. They had produced and presented a regulatory advance (albeit under pressure) and were trying to show how they would support its implementation. The questions that the contractors were asking were on the mark as well (I have omitted many excellent exchanges here). So despite some dopey DOE statements here and there and some exposures of this or that DOE requirement as being impractical in some situations -- and some troubling statements about evasive maneuvers in RPP production -- I came away from the meeting feeling that DOE was committed to improvement in rad protection and, especially, in safety oversight. For once, DOE seemed focussed.

#### ORNL Health Physics (Rad Protection) Procedures, 1994 Revision

Because DOE required the use of either the DOE RCM or a site-specific RCM consistent with it, the MMES central rad protection organization produced a common RCM for K-25, Y-12, and ORNL. ORNL

eventually was allowed its own RCM. ORNL decided to revise its set of rad protection procedures to constitute the ORNL RCM, incorporating all of the requirements of the DOE RCM plus some site-specific provisions. Thus a major revision to the ORNL rad protection procedures occurred in 1994.

I do not have a copy of the manual as it looked at this time, but the procedures were renumbered and their contents rearranged to correspond to the numbering and content of the DOE RCM articles. E.g., RP-6.3, on the design and modification of facilities, became RPP-128, "Radiological Design Requirements for New Facilities and Modifications to Existing Facilities". I ended up writing RPP-128 because design review was my area of expertise and because I was familiar with the other Orders (such as 5400.5, on rad protection of the public and the environment) whose provisions had to be incorporated.

I also wrote a new procedure to cover Article 129 of the RCM, on radiological optimization. Optimization is essentially a mathematical process of finding the best solution to a problem, but it requires some judgment to apply. In rad protection, the problem is that of balancing dose against expenditure, taking other factors into account. It requires the use of a dollar value of the man-rem. Setaro and I had discussed this several years earlier and his resulting two-tier value proposal had been approved by the ALARA Steering Committee. (The values had been proposed and explained in the literature by Dr. Baum.) There is also a need to consider the time value of money, for designs or operations that will be conducted over a period of years rather than weeks or months. Thus writing and applying a procedure on optimization was something to be done by a knowledgeable health physicist or an engineer who could do this sort of calculation. The authoritative guidance on the subject was in two reports by the International Commission on Radiation Protection (ICRP); DOE recommended use of this guidance. Within the rad protection organization, I seemed to be the only one who knew how to do optimization and was familiar with the ICRP guidance and the various papers dealing with specific cases.

I had also provided input to RPP-310, "Planning Radiological Work", which covered RCM Articles 311-316. One important change was for the AEG representative to sign the RWP to indicate that the review required by RPP-310 had been performed. The AEG rep would also document the review by memo, but the RWP signature would be a quick way of approval that would allow work to proceed immediately, without waiting for the memo to be completed and sent to the line manager to be placed in the operation or facility file. We thought that having the RWP signature constitute the AEG approval and authorization for work, instead of the documentation memo, was a practical and operations-friendly provision. Note that without the memo or a report, there was no written documentation of the rad protection review except what might appear on the RWP, which was written by the rad tech organization.

For RPP-310, I also provided a written rationale -- a technical basis -- for the choice of dose trigger levels. (These were shown in the revised version of the review level table previously given in this chapter.) We had not had a written basis for this before. However, I do not think this rationale was ever incorporated in any formal (technical basis) document, so that if an auditor had ever questioned our numbers and nobody could dig up my written document on short notice, our managers would have had to hand-wave through an explanation of how we got them. ORP management was always averse to "unnecessary" documentation regarding the origins of discretionary numbers and measures put into our procedures; this allowed ORP to change them readily by changing just the procedure, and not to have to bother with any underlying documentation. This was explicitly stated to me on more than one occasion.

#### Other Directives-Related Events

In May 1994, I wrote Sims a memo about design dose rates to be used for shielding. I told Sims that I had had two calls from people in the Engineering Division on waste projects and that because the issues were interdivisional (ORP, Engineering, and the Radwaste division), it would be best for him to make the call. The problem was that the Radwaste people didn't want any Radiation Areas outside a set of tanks: a Radiation Area, per the MMES RCM, was 5 mrem/hr or greater, but they were posting theirs at 1

mrem/hr to provide a cushion against exceeding the limit. Besides this, ORNL had its own posting level of 3 mrem/hr (a preference apparently of the rad tech section); the rationale was that if there was some variation in dose rates over time or an error in measurement, there would be some margin that would prevent an auditor or regulator from citing ORNL for exceeding the limit. So Engineering was confused about what to design to. Besides this, some older tanks had 3 feet of shielding, whereas calculations for the new tanks showed that only 2'-9" was needed. The Radwaste people still wanted the whole 3 feet (I conjecture so that in processing they could exceed the design specs in the future if need be), but DOE was questioning this on cost grounds. It was so unlike DOE to pay attention to something like that -- much less to question it -- that I thought it extra-important to resolve this on a sound technical basis.

So in my memo I pointed out to Sims that based on information from Engineering, it was the associated filters, not the tanks, that were the main contributors to the dose to the workers in the area. I had told them that this case was an obvious candidate for an optimization analysis, which was required by the RCM to be done when appropriate. Engineering had replied that if it were to be done, ORNL would have to do it since the design subcontractor would view this as a scope change and would demand extra money to do it. Although the DOE RCM had been out for almost two years, the contract for this work supposedly preceded that, so that Engineering claimed not to have known to put the requirement into the contract. (We in ORP generally did not get to review contracts or bid proposals and so were not able to point out omitted requirements in a timely manner.) Another Engineering person said that the Radwaste people on his (separate) project were also insisting on a 1 mrem/hr criterion for the shielding and they too gave as a reason that this would preclude having to post the area as a Radiation Area. This person and I agreed that the margin factor of 5 was excessively conservative. I asked the person rhetorically what he would say if DOE audited his project; he replied that he would defer to his client, the Radwaste division.

I then told Sims -- and I'm quoting for the relevance not only here but in later chapters -- "I suggest to you that although saying "If we design to 1 mrem/hr, we won't have any surprises and we won't have to control the area outside the shielding at all" has a certain superficial attraction, it is not a sound basis for justifying choices which result in a considerable expenditure of money. It's sure easier to pour concrete and then let it sit there for all time than to survey and maintain rad ropes. But from my talks with these engineers, I think it's not clear that they or [Radwaste] can justify such a level of shielding; it's not clear how frequently access is required at these facilities, what the dose (as opposed to the dose rate) is likely to be, and how much [rad protection] involvement will be required. Given the money that is being spent, clarifying what the doses might be would be well worth it. This is especially true since in both of these projects, there appears to be a facility or equipment whose operation provides historical data for predicting what these doses might be. There does not appear to be any set of consistent criteria for these people [Engineering] to follow, though; they tend to be somewhat acquainted with the high points of the Rad Con Manual as interpreted to them by [Radwaste], but they don't know 10 CFR 835 [to be implemented in 1995] and they certainly aren't very familiar with optimization".

I think that this paragraph would speak for itself to any fellow rad engineer. Obviously I was opposing excessive conservatism and proposing a little investment in an analysis that might produce a significant savings. At least it would have made the Radwaste people state their assumptions regarding the tank and filter contents, worker hours, distance to sources, etc. I pointed out that there was confusion among the designers and they needed some objective criteria to guide them. But Sims did not reply. I had asked that he get in touch with Mlekodaj or Mei or me, so he may have spoken with one of them instead of me. However, the result was that we did not give any official guidance to Engineering that I know of. Mei asked Gheesling, Geber, Utrera, and Alexander (of Nuclear Safety) to discuss this issue at our next group meeting and to "make suggestions" to Sims and Mlekodaj. She herself had received a call from a design engineer (in Engineering), who said he had been using the DOE RCM, but was unaware that there was an MMES RCM. His division rad control officer could not help him, so he was told to call Mei.

I am sure that the optimization analysis was never done for the tank project as I recommended, because when I asked Mei about it, she said that once we had told the project about it, it was up to them to choose what to do. Nor did my management seem to have approached the MMES central rad protection organization. The last I heard, both projects were going to go ahead and pour all that concrete. I was disgusted with the outcome, because I thought that Sims, Mlekodaj, and Mei were unwilling to say forcefully "Here is what you need to do for us [ORNL] to be in compliance". As would happen so often in years to come, we peons would talk with our management and urge them to take a position that would benefit ORNL (and often the taxpayer). But then they would decline to exert their authority, or at least to put forward a strong position, in an area that we were arguably in charge of interpreting and ensuring compliance for within ORNL.