DOSE REDUCTION TECHNIQUES

I. Introduction:

At Hanford, facilities contain a myriad of radioactive isotopes that are located inside plant systems, underground tanks and the soil. These radioactive isotopes were created during reactor operations or were separated and concentrated during process operations. This requires our workers to deal with toxic and hazardous materials that have high levels of contamination and radiation from alpha, beta, gamma and neutron emitters. This complicates the cleanup process and makes performing the simplest radiological work more difficult.

It became obvious early that workers need to apply ALARA protective measures to keep their dose low and reduce the risk to the environment. New tools, equipment, and materials had to be obtained and employed in the field. In addition, better work practices were needed and we had to learn from our successes and mistakes.

The information in this handout is broken down as follows:

Fundamental Techniques for Dose Reduction
Operational Considerations
Radiological Design
ALARA Personnel

II. Fundamental Techniques for Dose Reduction: Time, Distance, Shielding and Source Reduction

A. TIME:

Reducing the time spent in radiation areas is an effective means of reducing dose. Radiation doses are directly proportional to the time spent in a radiation area. The techniques listed below are effective in reducing the time spent in radiation areas:

- 1. Preliminary Planning: Involve Radiological Control personnel early in the planning process to obtain input on radiation/contamination levels and possible ALARA protective measures.

- Review current surveys of the work area and travel routes. If current surveys are not available or adequate, perform job-specific surveys using Radiological Control personnel who are familiar with pre-job planning. If survey information is not available, planners will have to estimate conservatively and then revise controls during the job.

- Review lessons learned from previous jobs and results from the same job or similar work. Requires access to planning records containing surveys, air samples, dose reports, problem reports, RWPs, etc.

- Determine what air, electrical, ventilation, communication, etc., services will be required and coordinate their procurement and scheduling.

- Determine if a separate disassembly or prefabrication area should be established in a low radiation area.

- Determine if mock-up training is necessary to assure workers can complete the work efficiently. Even something as simple as familiarization with a new tool or walk-through of the work is very beneficial.

- Obtain necessary spare parts and special tools. Ensure parts and tools are on hand, not miles away. If equipment needs calibration or cutting tools sharpened, have it done before the job starts.

- Use a team approach to planning. Involve all major stakeholders and work together. Independent reviews of work plans voids the use of your best resource, your people's teamwork and synergy. Perform a job walk-down with the appropriate personnel.

- Use your crafts during planning; they are a valuable resource and can provide information concerning similar work or alternate tools that can be used. .

2. Preparation of Radiological Work Procedures

- Complete an ALARA review if the work exceeds the established "trigger levels".

- Walk-down the work area and determine if interference's or insulation should be removed or temporary covers should be installed on other components to prevent damage during work.

- Plan worker access and egress from the work area.

- Provide for necessary services (air, water, power, waste disposal, etc) and communications.

- Remove sources of radiation, if practicable. This could include flushing a hot spot to remove a source or isolating the source with a wall or barrier.

- Plan for installation of temporary shielding. This may require an engineering review to ensure the weight of shielding doesn't damage any components or equipment.

- Consider decontaminating the work area prior to the start of the job and after appropriate work steps during the job.

- Work in lowest radiation levels.

- Perform as much work as practicable outside radiation areas.

- Consider use of special tools or fixtures that will allow the work to be performed in less time with less skilled workers.

- Determine inspection requirements for Radiological Control and QA.

- Determine testing requirements during planning, not as an after thought

- Delete unnecessary work. If something can be repaired instead of replaced, it may save significant time and dose. Conversely, it may be better to replace a component, rather than wasting time to repair it.

- Minimize the discomfort of workers (weather, temperature, lighting, etc.). If work involves kneeling on hard surfaces, consider kneepads or portable pads.

- Estimate the person-rem needed to perform the job. This may include a time-motion study of each individual to determine the time spent in the radiation area. Compare the dose estimate with the number of available workers to determine if more workers need to be trained.

- Extremely complex work plans can lead to increased time in radiation fields. Keep plan detail sufficient to perform work, but not overly prescriptive.

- Develop standard controls proven to work and apply where needed. Standard controls and standard phrasing in procedures can reduce time in radiation fields. Remember, always assess each job and control separately. Be able to add or relax requirements as needed during the job. Sometimes standard controls won't fit and you may have to mix and match controls and work practices to accomplish radiological work.

3. Work Practices:

- Do the job right the first time. Detailed planning is essential in ensuring that workers are provided the opportunity to be successful.

- Brief workers prior to performing radiological work to ensure they understand what it is they are supposed to do, are staged to perform the work, and answer any questions they may have about the work steps and the expectations. This briefing should include the techniques necessary for dose reduction, contamination control, and waste minimization. Using scale models, drawings, photographs, and videotapes are ways to improve these briefings. Prejob briefings should be performed sufficiently before work execution to allow for any needed changes that are identified. The actual, required pre-job brief should be no more than a final check of readiness prior to execution of work. The pre-job brief is not the time to be training personnel on the task or working on coordination between work groups.

- Rehearse the critical work steps in a mock-up to ensure the workers understand the expectations, the tooling/engineered controls work properly and the technical work procedure is correct. Specialized mock-up training may be required to teach workers how to perform work operations in a realistic environment that duplicates the actual work area and conditions.

- Keep unnecessary workers out of the work area. Management tours of the work area are helpful in ensuring the numbers of personnel performing the work are proper and personnel are working in the most efficient manner. The final decision on the number of personnel should be decided at the pre-job briefing.

- Use electronic dosimetry, if available, to track dose and time in the work area. This dosimetry can be set to alarm if the worker gets into a high radiation field or their total dose is near a preset limit.

- Control access to High Radiation Areas so that anyone who has a need to enter must first convince a manager of why the area must be entered and what is going to be gained. If there is no value added, the entry should be denied.

- Consider color-coding systems in radiation areas to simplify routine inspections. By marking different components with different colors, it might be possible to reduce the time it takes to locate these components.

- Use specialized tooling to speed up work. Examples include: Use electric or

pneumatically powered wrenches for unbolting and re-bolting flange connections.

- Cutting machines mounted to the outside of piping can be set up quickly and will cut and bevel the pipe for welding in one operation. This simplifies the preparation of the weld area and eliminates the need to grind the end prep.

- Use a hydraulically operated shear to cut out abandoned piping, concrete, metal, etc., quickly if the piping is not going to be replaced. This is a great tool for D&D.

- If the piping is going to be replaced, consider installing piping that has removable plugs that allows for the insertion of flexible hydrolyzing equipment if it becomes highly radioactive later.

- Use engineered and administrative controls to reduce the use of respirators, in order to increase the worker's efficiency and decrease the time in the radiation area. Wear face shields instead of respirators if the concern is to keep the workers from touching their face.

- Select protective clothing based on the expected contamination levels, stability and the form the contamination is in. Wearing the proper PPE ensures that contamination will not be spread in the work area or onto worker's clothing or skin. This would create problems in recovering from the incident and increase the time workers would have to remain in the work area. Excessive PPE requirements hinder the worker, increase the potential for heat stress and require more time to dress/undress.

- On jobs where respiratory protection is required and/or heat stress is a possibility, consider using air-fed hoods instead of full-face respirators. The breathing air helps cool the worker's body and the workers perform more efficiently. Getting certified breathing air takes some effort, but on a long job, the benefits can exceed the effort to install the air system.

- Use experienced workers to perform critical work steps in radiation areas. A dedicated crew of experienced workers can often times perform the work faster than a crew of inexperienced workers. On work steps requiring more than one worker, use an experienced and non-experienced worker as a team.

- Videotape portions of the work on longer jobs to use for training new workers and for historical files/lessons learned.

- The two-man rule used for safety often results in two personnel entering a radiation area to accomplish the work that could be done by one person. Consider using cameras to monitor personnel rather than doubling the dose by sending two

personnel into the radiation area.

- Scaffolding or staging erected in radiation areas takes time and exposure to install and remove. Consider leaving it installed for repetitive work, using movable scaffolding, or modify the facility with permanent equipment.

- Digital cameras have been developed that create photomaps of High Radiation Areas. The camera is downloaded into a computer, the images refined, components are labeled, and the high radiation areas are marked. The finished photograph is black and white but the high radiation areas are shown in colors.

- Test run tools and equipment prior to entering area for work. If the tool needs to be sharpened or a gage calibrated, do it before the job starts. Make sure extra saw blades, drills, or other equipment that might be needed is available.

B. **DISTANCE:**

Distance is the second of the dose control methods and can be more important than time spent in a radiation field. When dealing with a single source, the radiation level drops quickly as you move away from the source. By maintaining distance from the source, the worker can spend more time in the area and receive less dose. The following techniques use "distance" to reduce dose:

- In a mixed radiation field where radiation is coming from many different sources, it is important that the workers understand where the sources are and the radiation levels in the work area.

- Workers should know where the "hot spots" are located as well as low dose "standby areas" where they should move to if the job has a short delay.

- Look at the worker's body positions during the job walk-down. Instruct the worker to stay as far away from the radiation source as possible. Determine if the worker can reposition themselves to a lower radiation area.

- Use remote operating/handling tools when possible.

- Use closed circuit television to monitor work areas or components so that personnel can still perform the necessary inspections and oversight without entering radiation areas. Cameras are available that tilt, pan and zoom in and out. They can be color or black/white and be constructed of radiation hardened materials for use in High Radiation Areas. Telemetry dosimetry systems that use an electronic dosimeter with a transmitter can be added so that personnel can

watch the workers on CCTV and track their dose at the same time.

- If high level radioactive sources or waste have to be moved, consider using wheeled carts or equivalent to allow personnel to perform the movement without getting near the high dose areas.

- The type of cutting equipment chosen to cut highly radioactive piping can have a significant effect on radiation dose. Workers have to get close to the piping to install/remove a cut-off machine or to use a porta-band saw. A German saw or saws-all can be used with the worker positioned farther from the pipe.

- Robotics should be considered when performing highly radioactive work in confined spaces in order to reduce dose. Robotic devices and manipulator arms used on-site include tractor devices for inspecting piping, remote arms for handling equipment underwater, and special arms for sampling and monitoring the internals of underground tanks. Micro-robotic devices have been developed that resemble a "bug". These devices can crawl through small pipes and cracks to perform inspections. High dose savings are anticipated.

- Move the work to lower dose rate area, if possible.

- A new tool on the market is a gamma camera that will provide a black and white image with the highest sources of gamma radiation shown in color. This allows you to find the highest sources at a safe distance and plan how the sources should be shielded or isolated without having to enter the work area for hand-held radiation surveys.

C. **SHIELDING:**

The types of shielding used to reduce dose rates are dependent on the type of radiation and its energy level. The decision whether to install temporary shielding or not can be complicated in some facilities, therefore, Radiological Control should be consulted early in the planning phase. An evaluation as to whether to use shielding, which type to use and all aspects of shielding use has to be completed. Facilities that have an aggressive temporary shielding program have demonstrated the most success in reducing dose. The following techniques use "shielding" to reduce dose:

- Perform a dose estimate and calculate the dose to perform the work without installing temporary shielding. Compare the results against another dose estimate to install, maintain and remove the temporary shielding. Normally, temporary shielding is not installed unless there is a net savings in the total dose for the job.

- Consider staging temporary shielding near a radiological work area if there is a possibility that highly radioactive waste or components will be encountered during the job. This shielding could be installed quickly to reduce work area dose rates. We call this "process shielding" and it can be installed even though there is no engineering review, written procedure, or label applied. Workers have to use common sense not to break or damage anything by placing too much weight on a component or equipment. It can be only used for short periods.

- When handling highly radioactive samples or sources, thicker protective gloves that contain lead can be worn which will significantly reduce the beta radiation dose rates. Surveys have shown as much as 80% reduction in extremity dose rates by using the leaded gloves.

- When working on radioactive waste tanks or systems consider leaving water in the system to provide shielding to reduce dose rates.

- Some facilities have roll-around-shadow shields that can be placed between the hot spot and the worker.

- Radiation levels on the outside of glove boxes can be reduced by using lead bricks inside the glove box, leaded plastic for the windows and filling wall cavities with water.

- Water shields are tanks that can be positioned near a source and then filled with water, sand, cement or grout. These work well in facilities where there is no crane service to install heavier types of temporary shielding.

- Plexiglas, aluminum plate, and rubber matting are items that can be used effectively to eliminate problems with high levels of beta radiation. In mixed beta-gamma fields, shield the beta and then shield the gamma.

- Pre-plan your shielding installations as much as possible and only use what is necessary to reduce the dose rates or hazard. Most shielding is heavy and adds an additional injury risk to installation personnel. Installation personnel should have training on proper installation of shielding to minimize installation time.

- If high level radioactive sources or waste have to be moved, consider using shielded carts or equivalent to allow personnel to perform the movement in a lower radiation field.

D. **SOURCE REDUCTION/ELIMINATION:**

Source reduction/elimination means keeping radiation and contamination levels low or eliminating them altogether, so work can be performed with less risk and limit the spread of contamination. The result should be that workers will spend less time in the work area and not be exposed to high radiation levels. The following techniques of source reduction reduce radiation dose:

- Decontaminate the work area to reduce accessible contamination levels and plan for decontamination during the work steps to keep contamination levels low. By decontaminating the work area before the job starts, the work may be accomplished with less protective clothing.

- Cover areas with plastic or tape that are immediately adjacent to the location where high levels of contamination might be present during the job. This will make these areas easier to decontaminate at the end of the job, thereby saving time and exposure. On piping, cover the cut areas with tape, Vaseline, shaving cream, etc., to keep contamination from becoming airborne during cutting.

- If the area can't be covered, consider painting the area with strippable latex paint. After the paint dries it can be removed in long strips decontaminating the surface. The coating can be applied and the work performed in reduced protective clothing since it temporarily fixes or immobilizes high levels of removable contamination. Look for non-hazardous fixatives, there are many available for use.

- Consider the waste created during the job. Take actions to separate or keep separate, low-level radioactive waste from mixed waste during the job. By planning for waste minimization, time will be saved in the radiation area and disposal costs can be minimized. You may want to put two separate waste sleeves on a containment tent; one for mixed and one for low level.

- ALARA protective measures taken to reduce contamination spread often result in reducing the time it takes to perform work steps. Highly radioactive components can be raised into a sleeve to prevent the spread of contamination. This eliminates the time required to decontaminate the area later. Portable HEPA filtered ventilation units or vacuum cleaners that draw a suction close to the source of contamination not only help control contamination spread, but may reduce protective clothing requirements and decontamination time. Misting the work area with a light water spray or fixative has proven successful in reducing airborne contamination.

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- The use of "sticky pads" in work areas where there is a high probability that contamination will be tracked can reduce contamination spread.

- Chemical decontamination of piping systems or components has been used to significantly reduce dose rates. Chemicals are added to the system, allowed to soak and then flushed to a collection facility.

- If jobs involve vacuum cleaning high levels of contamination, consider installing a chip collector made from 30 or 55 gallon waste containers in the suction hose to collect the debris. Since the debris is already in the waste container, there is no need to empty the vacuum cleaner. In some facilities, HEPA filters are mounted to the inside of the drum lid so the chip collector will contain all the radioactive particles and prevent the vacuum cleaner from becoming a high radiation source.

- If a ventilation hose is placed in the work area to provide negative ventilation, the HEPA filter may become highly contaminated and become a source of high radiation. To prevent this, an in-line HEPA filter can be installed in the suction hose to collect the airborne particles. This filter can be easily shielded and changed when necessary without affecting the aerosol test of the system HEPA filter. At the end of the job, the in-line filter can be disposed in a radioactive waste container and the ventilation system upstream of the filter will not be a radiation source. Another type of in-line filter can be made by stuffing a housing with prefilter material and connecting a vacuum cleaner hose to each end. The prefilter material will remove the large debris without restricting the flow.

- Expandable spray foam is being used in ventilation ducts and piping to reduce the possibility of contamination spread during removal. Holes are drilled in the tops of the ventilation ducts and the spray foam is added to completely fill the internals of the ducting. Small spray cans are being used to add expandable foam through a small drilled hole at locations where horizontal piping is going to be cut. This forms a plug at the cut location and prevents airborne contamination and spillage during subsequent cutting operations. A variation of this technique also works well. A hole is drilled into the top of a pipe and grout is added using a cake decorator. The grout flows freely thorough the hole into the pipe forming a plug inside the pipe. After it sets up, the pipe can be cut and each section will have a grout plug in the end that prevents contamination from spreading. Several saw blades are needed to cut the pipe.

- Practicing waste minimization in the work area can save time later trying to separate hazardous and radioactive materials. A separate bag or containment sleeve for low-level and mixed waste is an effective method of minimizing waste.

Others ways to reduce the amount of mixed waste created include; use substitute materials that are non-hazardous, only take what you need into the work area, and cover hazardous materials so they can be surveyed and released at the end of the job.

- "Good housekeeping" throughout the job as well as at the end will significantly reduce the time it takes to recover from a spread of contamination.

- An aerosol generator has been recently used to apply a "fixative" to highly contaminated underground pits, rooms and vaults. A vendor mixes chemicals and then bombards them with sound waves to form an aerosol. This smoke-like material moves slowly down a hose and through an opening into the space. The aerosol completely fills the air space in the pit, room or vault and all surfaces are covered with a sticky fixative. Any airborne contamination present is encapsulated by the aerosol and deposited on the surface. This film captures all the removable contamination and prevents it from spreading. Work in these highly contaminated areas has been accomplished without any spread of contamination. Smear surveys show the removable contamination is very low, once the fixative has been applied. The fixative washes off easily when sprayed with water or rain. Potential uses in the future include ventilation ducts, fume hoods, glove boxes and process rooms at Plutonium facilities. In addition, a diluted strippable latex decontamination paint could be applied remotely using this technique and then the area entered by personnel who could strip the coating off, decontaminating the surface.

- Use confinement or containment to reduce the size of area that can be affected by a contamination spread and contain it closer to source. Glovebags, catch containments, and sleeving are examples of items that can be use to perform this function.

- Hydrolasing (high-pressure water cleaning) of piping and components prior to work, can reduce dose rates. Contact radiation reductions of 40-80% are typical.

- Establish decontamination techniques and obtain approved materials for your facility. Train personnel in proper decontamination techniques.

- Remove the radiation source if at all possible. Many times facilities have old abandoned systems that are no longer used but still expose workers that are nearby. Have these systems removed if they are no longer needed.

- Establish contamination action levels at which the job must be stopped and the area decontaminated. Keep contamination levels low , but not so low that you spend an inordinate amount of time decontaminating the areas.

III. Operational Considerations

The previous section discussed methods used to minimize time, maximize distance, increase the effect of shielding as it relates to specific work task planning and execution, and reduce the amount of radioactive material present. As ALARA professionals, we must also consider how the operational aspects of our facilities can affect worker dose. The following are operational aspects that can be optimized to reduce worker dose.

- Review operational routine tours and compare to surveys to look for optimization opportunities.
  - Determine if the most efficient route or path for completion of required readings is used.
  - Determine if data is being recorded or actions performed that no longer have a use or is no longer required.
  - Look for items that are not required but have been added for some reason no one can remember. Over time, routines have a knack of "evolving" and these evolutions can upset the best-laid out exposure control plans. Look for frequencies of routines that are greater than required.
- If valves are located in high radiation areas, it may be possible to install remote handwheels or operators that would allow the valves to be operated from low radiation areas.
- Review all routine procedures for work in radiological areas on some periodicity. The procedures used everyday have a tendency to "evolve" over time due to a change added for one reason, then another, then another, without a complete look at the whole evolution. The end result is a procedure that does not work or is very cumbersome. Look at the whole procedure and bring revise, as necessary.
- Perform an ALARA review of any new operational activity in a radiological area. It may seem like a small operation, but could affect dose performance.
- Train workers in dose reduction techniques. Ninety-nine percent of workers can quote the basic "Time, Distance, and Shielding" laws, but fail to have sufficient knowledge of practical methods to accomplish. This training is relatively inexpensive and can be accomplished in a non-radiological area. Skills such as containment use, contamination control methods, ventilation use, decontamination techniques, dress/undress refreshers, etc., can be taught.

- Use catch containments or sleeving under valves or other components that have a potential to spread contamination from leakage during normal operations. Confines contamination to easily controlled areas that are easily decontaminated. Valve packing tends to wear over time, gauge fittings tend to leak over time, etc. Minimizes your overall decontamination needs by controlling close to source.

- Train Radiological Control Technicians (RCT) and supervisors on basic systems design and component weaknesses. They cannot be an asset in early identification of problems unless they know where to look. Typically, RCTs have a limited systems knowledge and how common components function.

- RCTs that are familiar with designed pump leakage past mechanical seals, valve-packing characteristics, compression fitting weaknesses, identification of low points, problems with dissimilar metals, etc. are valuable when performing routine surveillance and investigative surveys. Many times the problem is only identified when it has become large enough to be a major problem that affects operations and resources.

- Perform in-process ALARA reviews of on-going operations for early problem identification. On long, complex jobs, don't wait until the job is completed to debrief it. Look for natural breaks in the course of the job that provide the opportunity to sit the workers down and listen to their problems, suggestions and record lessons learned.

- The ability to perform detailed dose tracking is necessary. Dosimetry, RWPs, access control, information retrieval, consolidation, and reporting must be coordinated to work together. Failure at any point can result in an inability to track dose to a sufficient level to identify trends or assess the effects of changes made to work plans, systems, or procedures. Dose tracking requires careful thought and continuous dedication.

- Keep workers informed of progress towards goals or success. Workers who have access to this kind of information tend to work towards that goal or success point.

- Industrial safety and Industrial Hygiene must be balanced with radiological safety. Look for conflict points and work to eliminate. There should be a close relationship with these other disciplines. Heat stress issues often involve all parties.

- Do not accept “that’s the way we’ve always done it”. Must constantly review processes and methods and look for ways to improve.

- A Planned Maintenance (PM) program for valves and other components is necessary. "Run to failure" programs lead to problems and higher dose overall.

- Keep a supply of dose reduction materials on-hand. Containments, sleeving, ventilation units, fixatives, decontamination agents, temporary shielding, etc., need to be readily available if they are to be used.

- Once a job starts, the workers gain experience, the contamination levels will be known, and the work practices will be perfected. At this time, Radcon personnel need to review the radiological controls and ensure they are adequate and not over-prescriptive. Often times, if the controls can be reduced, the result will be the job can be accomplished faster. This saves dose. There is a tendency to not change the controls if the job is going well, even though the controls could be reduced. Radcon personnel need to have the courage to make this decision, rather than “playing it safe”.

III. Radiological Design

Design aspects are frequently overlooked (or under-looked) in ALARA. There is a common misconception that “we are not building anything anymore” and the result is that the effects of a design on dose are not evaluated or very weak programs exist to evaluate design changes. Many times the tendency is to look at just the specific task and not the effect on the whole. ALARA input into design, whether a modification or new facility, is critical and fundamental to all other dose reduction aspects. More dose can be saved and a more cost-effective reduction can be obtained at the design level.

Other misconceptions are that engineers know what they are doing because they have been in the field a long time and their designs "must be ALARA". Engineering programs teach little or no ALARA techniques to their engineering students and in much of the industry, ALARA evaluations only discuss operational dose. ALARA decisions are based strictly on cost-benefit analysis. Aspects such as contamination control, airborne control, ease of maintenance, minimized maintenance, etc., are all aspects of an overall design that must be evaluated during the design process for maximum benefit. The following are some practical items in relation to design.

- A modification or new design must be identified early to ALARA and Radiological Control personnel. The earlier you are involved, the better optimized a design can be. Involvement should be as early as the budgeting stage. Involvement after key design decisions are made allow only for minor

changes to the design. This just passes the dose reduction burden onto the operational function. Items such as administrative controls, temporary shielding, respirator usage will have to be used to make up for the lack of physical controls in the design, which is not in keeping with regulatory requirements which require physical controls as the primary control method.

- ALARA personnel must be knowledgeable in mechanical, electrical, pneumatic, and structural systems, plus the ability to read drawings, etc. You do not have to be an expert in these areas, but you must have sufficient knowledge to be able to assess all aspects of a design. You also must be knowledgeable enough in these areas to be an asset to the design team.

- Prepare an ALARA review plan for the design. Lay out when and what is to reviewed and how optimizations and reviews are documented. Without a plan, good results will be a hit and miss proposition.

- Train engineers and planners in basic ALARA concepts. You cannot make them an expert in ALARA, just as you cannot be an expert in their areas, but teach them enough to ask questions.

- Integrate ALARA in all aspects of engineering for radiological facilities. Typically, they do the design and you get to implement. At the implementation stage it is too late to make up for poor design. Put ALARA reviews and evaluations into your engineering procedures. This is needed for any new design or design change.

- Use a graded approach to design reviews. Use more resources where they are needed, less on others. Your work planning procedure can take care of minor modification engineering reviews.

- Prepare a good, basic radiological design review checklist that has the ability to be modified for different projects. This is an invaluable tool in ensuring you don’t forget anything.

- Use a team to review designs when warranted. A team brings a lot of different views to the table and will result in the best review and in the end, optimal design.

- All aspects of a design must be looked at. From siting, traffic flow, contamination control, decontamination, storage areas, component reliability, maintenance, installation, airborne control, decommissioning, material selection, system layout, etc. All of these can affect dose.

- Use a measuring stick to gauge the effects of design changes. A dose estimate is the primary tool for this. Without a good dose estimate that is kept up as the design changes, you cannot effectively assess changes or make decisions.

IV ALARA Personnel

Another aspect that is frequently overlooked is the knowledge and skills needed by ALARA personnel in order to be effective. Your ALARA personnel are the center piece of your ALARA program. Without competent personnel, your program will go nowhere, regardless of the quality of your paper program. ALARA personnel must be experts in some things and knowledgeable in many others. Continued growth in personnel skills and knowledge is necessary to move a program forward. Too many times programs stagnate due to complacent people. Complacent programs lead to a lack of dose reduction in the field and typically lead to an increase in dose overall. Here are some things to keep in mind as you assess your personnel and even yourself.

- Always be looking for a better widget. Technology is constantly changing. A recently observed fact, is that the sum all the knowledge ever amassed in the world has doubled in the last three years. That is how fast the world and technology is changing. Stay tuned to new developments in materials and methods.

- You need to be "people persons". Be in tune with, not only the people you work directly with, but the crafts, management, other departments. Communication with others is a key to your success in reducing dose.

- Be a “resource”. Being the center-point between many other organizations in the concepts of ALARA, you need to have answers. This means knowing your facilities, processes, people, and available technology. Otherwise you are just a roadblock to get over or something they have to do.

- Be very organized. In being the ALARA center-point, typically there is more of “them” than of you. “Them” refers to those who you support. You must be organized in order to provide maximum benefit.

- Be tied into information. Information is a valuable asset in your business. Assessment reports, problem reports, audit reports, regulatory review reports, plant conditions, radiological conditions, etc., is important information for us to be effective. Look at the overall picture, which means overall information.

- Be in the field. Not only is this the best way to get to know the people, but to keep up on the facility and work in progress. Get out and see if the controls you planned are being effective. Talk to the workers about the work and note any suggestions.

- Be available. Not only by being visible, but have a multitude of ways to be contacted. Phone, fax, cellular, pager, radio, etc. Have them all and publish them. Let them know you are available.

- In a typical nuclear facility, ALARA personnel should have no other jobs. All too often we see ALARA as an extra duty for someone with a full-time job already. In this case, your program ends up being a paper program or a "fluff" program. By fluff, is meant handing out trinkets and putting up posters. There is a place for fluff in an ALARA program and it is an important part in keeping workers aware and recognizing good performance.

- Be inventive and creative. Without these qualities progress can be slow and sporadic. New ways and new ideas are corner stones to dose reduction. Look for new ways to use common materials. Lots of things are made for a certain use, but can also be used in dose reduction.

- Keep yourself in tune with what is going on in the ALARA field. Networking with other professionals is a good way to accomplish this. Another is attending conferences and seminars.

V. Conclusion

This document is not meant to be an all-inclusive list of ALARA techniques to reduce dose. It is a list of items learned over many years while trying to accomplish high risk radiological work. We hope it can help you in your goal of better dose performance.