OPERATOR SELECTION, TRAINING, AND EFFICIENCY IN THE FIELD OF REMOTE HANDLING

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INTRODUCTION

Many factors influence the selection, training, and work efficiency of operators engaged in handling dangerous radioactive material by remote control. Personnel are selected for intelligence, mechanical aptitude, interest and enthusiasm, physical fitness, and coordination. They are formally trained in the nature and hazards of the material to be handled, detection methods, and objectives of the facility workload. They are trained in the procedures, methods, and techniques by on-the-job experience demonstrated and taught by competent colleagues. Their efficiency is controlled by man-machine relationships, mental and physical fatigue, rotation of job assignments, stimulation of interests, and discipline.

Experience in the operation of a "Hot Laboratory" for the handling and evaluation of highly irradiated reactor materials has demonstrated a very real need for serious inclusion of Human Factors in the selection, training, and use of the staff. During the early growth period of this relatively youthful technology, facilities and equipment were developed and used by scientists and engineers who had a burning desire for answers and data. Their magnificent accomplishments in this difficult, frustrating, and somewhat alien technology are the foundations upon which we are still building. Today we continue to be motivated by the quest for increasingly sophisticated scientific data and techniques; but we are also facing competition and the necessity for decreased costs and increased efficiency. These newer goals are approached with a combination of better facilities and equipment, and improved integration and usage of staff. Since this is an intrinsically expensive technology and we are a long way from significant automation, our Human Factors problem is as important as our ingenuity in facility and equipment design.

OPERATOR SELECTION

All of the non-professional staff for the Hot Cells at Atomics International are expected to learn and perform all of the

myriad tasks involved in hot-laboratory operations. These include equipment development and installation, decontamination, waste handling, etc., as well as the actual conduct of examinations by remote control. It should be obvious that not all men are equally proficient in each of these types of work, but all are expected to become at least useful in them. The reason for adopting this "Jack-of-all-trades" requirement is twofold: (1) Logistically a Hot-Cell operation is many-faceted and requires skillful shifting of personnel to control radiation exposures and accomplish work requirements as they occur in the schedule. (2) To be effective at any one task, an operator must know and appreciate the problems inherent in the others. Thus, the man who actually remotely operates equipment inside a cell to accomplish an examination must know the equipment intimately, understand the experimental objectives, control the waste handling, consider decontamination, etc.

The qualities we look for in selecting operators are as follows:

A. Education and Age

We insist upon at least a high school diploma, and find that one or more years of college work is most desirable. All operators need to learn at least the fundamentals of nuclear phenomena, understand the detection instruments, comprehend the principles of personal dosimetry, be able to do arithmetic, learn photography, etc. Their ultimate progress and value to the operation is almost directly linear with their ability to learn and to apply their knowledge. The man who cannot learn well and apply what he knows intelligently may not only be a detriment but actually a hazard to the operation.

Age is not so rigid a criterion. We find that it is rare for a young man under 20 to show sufficient maturity and stability, and it is usually valuable for him to have had some work experience following graduation from high school. Men over 45 often do not satisfy our physical requirements, but no good generalization can be made for an upper age limit. In practice, few applicants over 45 fit our needs for various reasons.

B. Physical Condition

General health, physical condition, and sound functioning of all senses are more important in remote handling than in many other occupations. For this reason potential operators are given a more thorough physical examination than the average employee.

Vision must be normal, preferably unassisted by glasses. Glasses prove to be quite a nuisance when worn beneath a full-face mask, and it may prove dangerous if a man who is essentially

dependent upon them accidently knocks them off while engaged in a tense operation. We do not insist upon unassisted vision, but we do require that a man can move with reasonable assurance in an intricate environment without glasses. Depth perception is obviously important when an operator must perform precise, coordinated movements with a pair of Master-Slave manipulators.

Hearing must be normal and unassisted. Hearing aids are not acceptable since operators must also work in masks in the contaminated area and it would be too difficult to decontaminate the devices. If an operator worked only at manipulative tasks, this objection would be removed.

We accept no one with back trouble, asthma, heart disease, epilepsy, chronic sinusitis, etc. These requirements stem from the nature of strains imposed by working in protective clothing and face masks, and the difficulties involved with getting a contaminated man medical assistance in a hurry.

Good muscle tone, general fitness, and coordination are obviously essential. Remote operating is tiring, both physically and mentally, and the man must be able to do at least a two-hour stretch at the manipulators without placing his reliability in jeopardy by fatigue. Eye-hand coordination in remote manipulation is, of course, a must, since the consequences of a "missed" manipulation can be so very great. To date we have not introduced testing for this quality, but it is under consideration for the future.

C. Personality

This is a difficult category to discuss since assessments cannot be assisted by measurement. Interview techniques must be tailored to each applicant to bring out some determination of the following qualities:

1. Fear of the job, its environment, and the nature of the materials to be handled. This is hard to assess since it is normal for a man to fear an unknown hazard. The quality to look for is an ability to change fear to respect after some knowledge and familiarity has been acquired. A man who continues to be frightened after a normal acclimation period is useless since he cannot be depended upon for proper independent judgements during the period of his technological growth.

2. Mental stability and calmness. An excitable or "nervous" man often implements ill-considered judgment when confronted with a sudden hazardous or unexpected situation. Such a man can cause much damage, both to the integrity of the job and to other workers. An orderly attitude in the face of adversity is essential.

3. Interest in the job. It is most important that this be well developed in the applicant interview, since we find it an essential quality. The mechanical actions performed as an operator are often tedious and tiring, and the other occupations required of the hot-laboratory team can be arduous and uninspiring. An interest in the pioneering aspect of research and development, an enthusiasm for a relatively exotic occupation, and perhaps an excitement over the chance to work in nuclear energy programs is most desirable in an operator. This has a very real advantage in stimulating the reliability factor in remote operations. Close supervision is often practically and economically impossible, and the interest shown by the operator in doing a good job bears a very direct relationship to the reliance which can be placed upon his work and to his increased usefulness and progress.

4. Maturity. While this is not necessarily a personality trait, neither is it a pure function of age, education, or physical condition. It is important that an operator be sufficiently mature to recognize the serious responsibilities of his job, the reasoning behind procedures, the potential hazards, and to discipline himself accordingly. Without this quality, regardless of other skills, a man cannot be used for this type of work.

D. Mechanical Aptitude

Since nearly all of the jobs which a cell operator is expected to perform require at least the use of complex mechanical, electrical, electronic, and hydraulic equipment, he must have this quality called "mechanical aptitude." Long mechanical experience is not required, obviously, since we accept men from 20 years of age and up. However, the man should at least demonstrate some experience and interest in "things mechanical," such as having worked on cars, boats, motorcycles, etc. We have had some experience with men who did not possess this aptitude, and were forced to either use them in another specialty or to transfer them to another type of occupation.

OPERATOR TRAINING

Since it is very seldom that an applicant comes to us with previous experience in remote handling of radioactive material, we must train each worker. We employ very little formal, classroom-type training methods, not because they are undesirable but because we have not been able to spare experienced men for instructors. Thus, our program consists almost entirely of on-the-job training by competent staff members and Health Physics personnel.

The only more-or-less formal instruction given new people is in the fundamentals of radioactivity, biological effects of radiation, personal dosimetry, detection instruments, and procedures to control health and safety. It is obvious that a worker must know something about his environment, and how to move safely and in confidence through and around it.

Instruction in the mechanics of remote control, types of equipment used, problems and procedures in handling radioactive materials, etc., are easily handled by on-the-job training using methods which are not much different from those employed in more classic occupations.

Perhaps the most important training occurs at the last stage when an operator is ready to start cell work. This requires that he know a great deal about the nature of the experiment in progress. The operator must appreciate the purpose of the job, its importance, and the kind and quality of data required. This not only stimulates interest, but provides the proper basis for intelligent operations. Supervision is necessary, of course, but cannot be applied 100% of the time and much responsibility must be committed to the discretion of the operator.

OPERATOR EFFICIENCY

Controlling and increasing operator efficiency demands a great deal of attention from the management of a remote-handling facility. In this respect we are not different from other enterprises which produce a product, except that our product is intrinsically very expensive and any factor in our operations which is " x%" inefficient reflects a large dollar and schedule deficit.

Operating a hot-laboratory facility is logistically a many-faceted problem, but in each facet operator efficiency appears as a common denominator. It is apparent, then, that operator efficiency also is composed of many ingredients and we can discuss them briefly as follows:

A. Selection and Training

Since these subjects have already been treated, we mention them here only to point out that the first step toward efficiency involves choosing and teaching the personnel.

B. Man-Machine Relationships

In general, every effort must be made to design equipment, procedures, and regulations to produce safe and comfortable relations between the man and his job assignment. This pays off not only in morale but in efficiency, since the man can expend a maximum of attention, effort, and concentration upon successful

completion of an operation with minimum concern over creature comfort and worry.

One aspect of man-machine relationships is fatigue. In any remote-control operation two types of fatigue affect the operator: nervous tension resulting from apprehension over the responsibility involved, and physical fatigue from muscular exertion in manipulation, awkward body positions, and standing up for extended periods. Fatigue causes accidental damage to equipment or to the integrity of the experiment, slows reaction time, and blunts the validity of the quick decisions which must often be made. Thus, supervision must monitor the operators carefully and insure that men do not unconsciously work beyond their fatigue threshold for this type of effort. Illustrative of the importance of this aspect is the fact that operators rarely can manipulate at a cell station for longer than two hours without a "break." Manipulators and in-cell equipment are thus designed, wherever possible, for maximum reliability and ease of operation.

There is an interesting point concerning the reliability of machines. We all realize that perfection is never achieved in a machine, and, therefore, at least one alternate method must always be available for accomplishing a remote-handling problem. This precept adds to efficiency in man-machine relations since it not only provides insurance that a given job can, indeed, be accomplished, but it retains for the operator the stimulus of having a vital role to play if the machine fails. If pushing the button fails to accomplish the purpose, the operator can feel that he is able to excercise his ability and intelligence to accomplish the end with perhaps more primitive, but nevertheless effective, methods.

Perhaps a final, but extremely vital point concerning the relationship of man to his remotely controlled machines is the necessity for maximum simplicity of design and operation. We are here confronted not only with the usual desire for the reliability, low maintenance, and long life associated with simplicity of design, but with psychological reactions of the operator. When a man is confronted with the assignment of operating a very intricate device whose controls are complex and "touchy," he first experiences a fear of making mistakes. Practice and familiarity soon overcome this fear, and exhilaration takes its place as success is demonstrated. Buoyed up by this exhilaration, the man can easily become the victim of either contempt or unconscious fatigue brought on by nervous tension. The result of these human frailties is often disaster to the experiment or to the equipment. It is better by far to design maximum simplicity into controls and actuations so that the man acting as "the brain" is not unduly challenged in memory, dexterity, or physical condition.

C. Discipline

As we paint our picture of an operator selected and trained for remote-handling work, he emerges as a very high-quality individual. He must be led along the paths towards efficiency, and when he requires driving it must be done with rather more finesse than a bull-whip. With such men the most effective discipline is accomplished by increasing their knowledge and appreciation of the problems at hand, and establishing their vital positions in affecting a solution. If this method fails, simple expedients which injure pride or reduce responsibility usually succeed very rapidly. In the few cases where industrial disciplinary measures seem required, the individuals concerned constitute a mistake of selection and should be assigned to some other occupation.

The usual disciplinary problems arise from violations of procedures, too relaxed work habits, or too enthusiastic assumption of responsibility. We must tread a narrow line in dealing with these problems since we are concerned with people whose aberrant behavior is often pointing towards progress along an unrecognized path. It is true that many difficulties are clear, but it does not pay to ignore the cloudy aspects since they may well point up weakness in organization or planning.

There are obviously many other things which affect the efficiency of remote-control operators, but most of them would emerge as details under the foregoing headings and would require much more space to discuss.

We are still dealing with a youthful technology, and we realize that there is much to learn both about our technical problems and our use of people. There is nothing mysterious in the solution of problems concerning human factors in remote handling; it just takes time, money, and experience to solve them.