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NIOSH STATEMENT OF EDWARD J. BAIER AT THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, U.S. DEPARTMENT OF LABOR INFORMAL HEARING ON PROPOSED STANDARD FOR DIVING. HELD IN NEW ORLEANS, LOUISIANA ON DECEMBER 20, 1976

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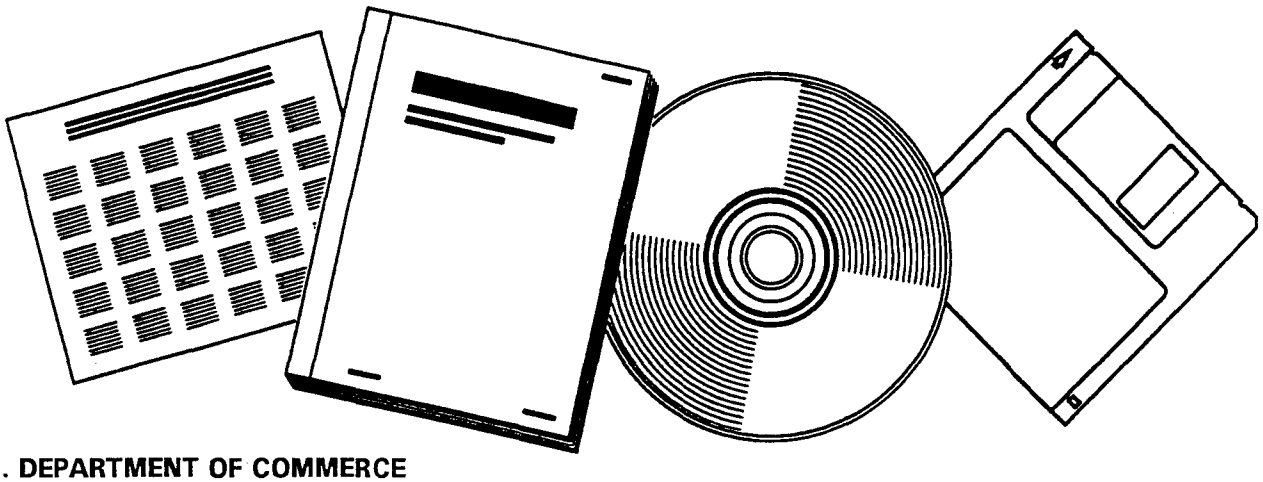

U.S. DEPARTMENT OF COMMERCE
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STATEMENT OF
EDWARD J. BAIER

DEPUTY DIRECTOR
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CENTER FOR DISEASE CONTROL
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

AT THE
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
U. S. DEPARTMENT OF LABOR
INFORMAL HEARING

ON

PROPOSED STANDARD FOR DIVING
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16. Abstract (Limit: 200 words) This testimony concerns the activities of NIOSH in relation to the establishment of certain guidelines for safety in the diving profession. A report on recommended diving standards was delivered to OSHA by NIOSH on August 18, 1976 to aid OSHA in the development of a final standard. NIOSH was beginning a major epidemiologic study which will be concerned with an assessment of the mortality experience of divers, a cross sectional morbidity study to help determine the current health status of divers, and an evaluation of the need for improved surveillance of injuries and illnesses resulting from, or correlated with commercial diving. The comments in this testimony also relate to the evaluation and improvement of diving tables, decompression sickness and resultant tissue damage, the early detection of decompression sickness, and the listing of absolute physical disqualifiers. A scheme to lower the current incidence of bends was adopted by OSHA. The statistical approach taken by OSHA was supported by NIOSH. It is recommended that OSHA institute a reporting system for diving incidents. NIOSH finds the use of disqualifiers to be justified in the case of professional diving due to the extremely arduous conditions normally found, and even more stressful emergency conditions.

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b. Identifiers/Open-Ended Terms NIOSH-Publication, NIOSH-Author, NIOSH-Testimony, Baier-E-J, Diving-industry, Worker-safety, Regulations, Physical-stress, Decompression-sickness, Medical-treatment

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Accompanying me today are Dr. Frank L. Mitchell, NIOSH Division of Criteria Documentation and Standards Development, and Dr. Alan H. Purdy, NIOSH Office of Extramural Coordination and Special Projects.

INTRODUCTION

NIOSH has long recognized that the diving profession is a dangerous one. In addition to the immediate problems of death and injury to workers while actually diving, NIOSH has been concerned with the long-term health effects that may occur in divers. As a result, NIOSH has sponsored such projects as a Symposium on Dysbarism-Related Osteonecrosis which, in 1972, focused on the long-term bone effects of the diving profession. In cooperation with the Energy and Research Development and Administration (ERDA), National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), and the National Heart and Lung Institute of the National Institutes of Health (NIH), a study having the title, a "National Plan for the Safety and Health of Divers in Their Quest for Subsea Energy" was published. This study discussed many of the health and safety issues of divers.

The Occupational Health and Safety Administration (OSHA) was petitioned on August 8, 1975, by the United Brotherhood of Carpenters and Joiners to issue an Emergency Temporary Standard (ETS) for diving operations. To assist OSHA in development of a standard, NIOSH issued a contract in February 1976 to Tarrytown Labs, Inc. to develop a report on recommended diving standards. A project officer was assigned to monitor the report, which was delivered to NIOSH on August 16, 1976. Because OSHA had already issued an ETS on

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June 15, NIOSH forwarded the report immediately on August 18, 1976, so that OSHA could use it in developing a final standard. It was recognized at the time, however, that there were certain issues requiring further evaluation.

While not necessarily in agreement with all that the Tarrytown report contains, NIOSH considers this report and its recommendations to be a significant advance in worker safety and serves as a basis for further scientific investigation. This will, in turn, facilitate developments in such areas as early diagnosis of decompression sickness, and the evaluation and improvement of decompression tables used by the industry.

During the course of the development of the Tarrytown Labs report, NIOSH worked closely not only with OSHA and the contractor but also with other interested agencies and groups, including the U.S. Coast Guard, the National Oceanic and Atmospheric Administration, the National Academy of Sciences, and the Marine Technology Society. In addition, the Underseas Medical Society was a subcontractor to Tarrytown Labs.

It became apparent that the time and manpower required to develop a complete NIOSH criteria document on diving would not be feasible without major disruption of other NIOSH activities. Therefore, NIOSH has developed position papers on three of the most important issues which further define the current conditions, NIOSH recommendations, and has also identify potential areas for further NIOSH investigation and evaluation. These issues are the evaluation and improvement of diving tables, early detection of decompression sickness, and the identification and application of absolute physical disqualifiers as part of preplacement medical examinations.

To further define what is, after all, the major issue under discussion here, the health and safety of divers, NIOSH will begin a major epidemiologic study which will concern itself with, among other things, the following major topics:

1) An assessment of the mortality experience of divers;

2) A cross-sectional morbidity study to help determine the current health status of divers; and

3) Evaluation of the need for improved surveillance of injuries and illnesses resulting from, or corollated with commercial diving.

As an immediate step, NIOSH strongly supports the concept of an intensive medical surveillance and examination program as outlined in the proposed standard.

I will now turn to the issue papers which will, in more detail, explain some of the important issues in the derivation of medical and operating standards for commercial divers.

ISSUE - DIVING TABLE EVALUATION AND IMPROVEMENT

The problems of placing a man under increased pressure (compression) and safely returning him to normal air pressure (decompression) are of primary importance to the success of underwater work. In its attempt to ensure that the health and well-being of workers involved in diving operations are protected, especially in dives deeper than 190 feet, NIOSH has been concerned by the lack of availability of laboratory and field documentation pertaining to the development of decompression tables. NIOSH believes any level of decompression sickness is unacceptable in humanitarian terms and in relation to the goals of the Occupational Safety and Health Act. At the same time, however, NIOSH recognizes the dangerous nature of diving. Of the issues involved in writing standards for commercial diving, diving table evaluation and improvement are unquestionably the most complex.

To work freely underwater, a diver must breathe gases at elevated pressures. The diver's body tissues absorb large amounts of dissolved gas during this process, and it is essential that, upon surfacing, these tissues be cleared of this dissolved gas without causing ill effects. Unless the dissolved gas absorbed at increased pressure is eliminated, the diver may suffer pressure-related injury or illness. Decompression sickness can appear immediately in acute form, or in many cases years later in the form of chronic disease.

Inadequate decompression after an air dive may cause decompression sickness or other forms of pressure-related injury. The presence of separated gas in some relevant tissues of the body is generally believed to be the primary cause of acute decompression sickness. Acute decompression sickness can be

manifested in a variety of ways, ranging from itching of the skin, to limb pains (bends), paralysis, audio-vestibular involvement, or collapse and death. The etiology of the chronic forms of decompression injury, such as dysbaric osteonecrosis, or aseptic bone necrosis, is not well understood. The vast majority of cases of acute decompression sickness are apparently satisfactorily treated by recompression therapy. The principal therapeutic tables in worldwide use are those given in the U.S. Navy Diving Manual.

Decompression sickness encountered in mixed gas diving, that is, diving in which other gases such as nitrogen and helium are used with, or in place of air, generally takes the same form as outlined for air diving. However, in this type of diving, it is not uncommon for acute decompressison sickness to occur while the diver is still under pressure. Also, there is a marked tendency toward involvement of the audio-vestibular system, affecting both hearing and the sense of balance, at times resulting in permanent damage. The U.S. Navy's therapeutic recompression tables do not provide adequate security in these circumstances. As a result of these limitations, numerous ad hoc procedures are being used by those currently involved in commercial diving.

It should be noted that although discussions of this subject mention successful decompressions, it cannot be assumed that they are, in fact, successful. In other words, has the compression and decompression been accomplished so that no acute or chronic effects will remain? In view of the increasing knowledge of long-term effects such as dysbaric osteonecrosis, much work needs to be accomplished before a true definition of successful decompression can be made.

Even though no symptoms of decompression sickness may appear to be present, most so-called successful decompressions show a considerable amount of free gas in the blood and apparently in other tissues of divers. Existing evidence shows that gas/protein interfaces in the body fluids cause denaturation (shape and activity changes) in certain of the proteins. In blood, this causes clumping and destruction of the red blood cells and may trigger the clotting mechanism. It is reasonable to assume that similarly destructive activity takes place in the other cells of the body.

After each presumably successful (or unsuccessful) decompression, the blood platelet count drops for several days, indicating tissue damage. Electron microscope photographs of blood vessel walls under these conditions show platelets clinging to damaged walls of blood vessels. Further, dysbaric osteonecrosis is known to occur as long as or even longer than 10 years after a series of apparently successful decompression.

Thus, most decompressions apparently take their toll of tissue damage even when obvious symptoms of decompression sickness or other pressure-related injuries do not occur. It is apparent from the foregoing that considerable amounts of tissue damage may take place in practice since the rate of bends is from about 1% for air dives to about 14% for deep-mixed gas non-saturation dives.

A representative performance criterion has been proposed by Tarrytown Labs in their recent report to NIOSH. The Tarrytown evaluation scheme for decompression tables was based on the following data, which must rank highly in any effective evaluation of decompression tables.

1) The time/pressure profile

2) Type of dive

3) A record of decompression sickness incidents with each table

The Tarrytown report identified the difficulties, based on present knowledge, in meeting a performance criterion of 0% incidence of decompression sickness. Therefore, the report recommended a scheme which would lower the current incidence of bends and provide a data base essential to lowering the incidence towards 0%. Such an approach has been adopted by OSHA in its proposed standard.

NIOSH supports the statistical approach taken by OSHA and the necessary corollary of automatic recording of data associated with dives to depths greater than 190 fsw. The Occupational Safety and Health Act, however, sets as a goal that all workers be protected against occupationally related injury and illness. Until research on safe diving tables has reached a point that they can be confidently relied upon, knowledge gained from current on-the-job experience needs to be compiled. However, obtaining adequate information on current practices and the scientific evaluation of them will require assurance that the data are accurately and comprehensively reported.

Diving tables most widely used today are based on experience and many companies have developed their own diving tables. Many diving situations take place with guidance from sources that may, or may not, be reliable under prevailing conditions. Also, it cannot be stated with any reasonable degree of assurance that a single set of tables can be developed that would protect the diver under all operating and working circumstances.

To help meet this situation, a recommendation is made that OSHA institute a reporting system which would require that any diving incident requiring the services of a physician or, when available in adequate numbers, an emergency medical technician, be reported to OSHA along with all pertinent details surrounding the injury such as conditions of the dive, gas mixtures used, the dive schedule that was being used, and other information considered pertinent, including the employers plans to modify the schedule so as to prevent a recurrence of the incident. This information could then be monitored on a continuous basis, and appropriate action taken by the regulatory agency if it is observed that employers are not operating under safe and healthful conditions. The result would be a vast increase in the available information which would not only enhance the scientific study of hazards in this industry but would also be another significant advance in protecting the safety and health of the workers involved. NIOSH would assist in this effort by means of aiding in the interpretation of data, locating consultants, and other appropriate means.

ISSUE - EARLY DETECTION OF DECOMPRESSION SICKNESS

Throughout modern diving history, the method of detecting and diagnosing decompression sickness has been by means of observation of the diver for the classical signs and symptoms of the disorder. The onset of decompression sickness can be heralded by the appearance of a variety of symptoms such as itching skin, dizziness, or shortness of breath (the "chokes"). The usual initial symptom, however, is pain. This can vary, but is most commonly a localized pain in an extremity, at first vague, but growing progressingly worse. In addition, of course, there are combinations of these symptoms, varying in intensity from mild to severe, and of variable duration.

For many years investigators have attempted to devise a means for detecting decompression sickness prior to the onset of these symptoms. The symptoms usually occur 3 to 4 hours following completion of a dive, but can begin earlier or later. These studies have not been notably successful in developing useful and practical screening methods, although some, such as blood gas determinations, are useful in the laboratory and in the experimental diving situations.

The one technique which does appear to hold great promise is the Doppler ultrasonic bubble detection method. This device operates on the basis of audibl detection of bubbles in body tissues. It has been the subject of a great deal of experimentation, and is now advanced to the point that it is used in investigations in decompression chambers. In addition, it has been used

in some screening of divers on-site and has been found to be effective. It is our understanding that although bubbles have been detected in divers who did not develop acute symptoms, there are few cases of fully-developed decompression sickness in which bubbles are not detected.

It is also our understanding that the device is not developed to the extent that it is ready for use in all routine commercial diving situations and locations that would be covered by the proposed standard. There is not yet a hardware configuration that appears satisfactory for all applications, and in addition, there is a problem of interpretation. This latter problem is primarily one of training. While professionals and technicians may use the technique, it does require time to learn, and there are not a great number of centers that can provide the training.

Unfortunately, it now appears that there is no other practical and reliable method available that will allow detection of decompression sickness prior to the onset of symptoms in the diver. In an attempt to find an early solution to this problem, a research project will be considered by NIOSH to determine whether the Doppler technique can be brought to the level of development that will allow reliable early detection of this condition.

NIOSH further supports the concept of Emergency Medical Technician/Diver as discussed in the Tarrytown Labs report. This member of the diving crew, who would combine the knowledge and experience of a diver with appropriate medical training, would add a significant dimension to diver health and safety. Even in the absence of a reliable early detection

method, having trained personnel available would be valuable not only for the obvious advantage of immediate medical care and treatment of decompression sickness, but also for the increased awareness of medical factors that such personnel would bring to the entire diving team.

ISSUE - LISTING OF ABSOLUTE PHYSICAL DISQUALIFIERS

In past criteria documents, it has been NIOSH practice to define those conditions which, if present in a worker, could be aggravated or made worse by exposure to the substance or situation under consideration. A statement is then made in our documents that the responsible physician consider those employees with those conditions for exclusion from exposure. Thus, the ultimate decision is left to the judgement of the physician. In the case of the contractor's report on a recommended diving standard, there is a list of conditions which, if found to be present, are mandated to be absolute disqualifiers for divers.

As with aviation, routine work operations can possibly be carried out by a worker with certain abnormalities. In an emergency situation, however, where not only his own, but other lives may be in jeopardy, physical conditions which add to the already existing stress should not be allowed. As examples from this list, significant heart or pulmonary disease, as well as certain blood abnormalities or central nervous system disorders should not be present in active commercial divers.

NIOSH finds that the list as presented in the report is widely accepted by physicians involved with the diving problem. In most cases, workers applying for diving positions are not hired if they are found to have any of the conditions listed as absolute disqualifiers. A real problem with disqualifiers is that diving may, in fact, cause the very injuries that would not allow the diver to continue in his occupation if he left his current employer and sought employment with another diving contractor. The application of disqualifiers to experienced divers needs to be further explored.

As a result of these factors, NIOSH finds the use of disqualifiers to be justified in this instance due to the extremely arduous conditions normally found in the occupation of professional diving and the even more stressful conditions which can occur in emergency situations. It is not, however, the general policy of NIOSH to endorse absolute physical disqualifiers.

This concludes our prepared remarks. If there are any questions, we would be pleased to address them.

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