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Diving in nuclear power plants

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nuclear diving contamination
radioactive operations
Oceaneering International

Oceaneering International, Inc., together with its affiliate companies, is the world's largest publicly owned underwater services company that specializes in manned and robotic underwater services, survey and positioning, search and recovery, engineering, project management, and inspection. The majority of services are provided to the offshore oil and gas industry and include underwater drilling support; subsea engineering and construction; production systems management; and facilities inspection, maintenance, and repair.

Underwater maintenance in nuclear power stations is becoming an established and very sophisticated segment of the nuclear service market. There are approximately 105 commercial nuclear power plants in operation in the United States, which produce over 17.7% of the country's electricity, and there are 11 reactors with construction permits. Reactors use uranium fuel assemblies to produce heat, which in turn boils water; the steam turns turbines to produce electricity. The fuel assemblies are stored and refueled underwater in fuel storage pools, which contain very clear, boronated water approximately 40-ft deep and have a lining constructed of stainless steel, the metal used for the majority of the equipment in the pool. Filters are used to remove radioactive contamination and maintain excellent visibility.

Divers remove and replace fuel racks, inspect and repair transfer equipment, and perform inspections of equipment and structures in the pool. The two most important concerns of the diver are radiation and temperature. Radioactivity, the emission of energy from the nucleus of an atom, has four types: neutron, beta, alpha, and gamma. Beta and gamma radiation concern the diver. Neutrons are only a factor while the reactor is operating, and alpha radiation only travels about 1 in. in air and can be stopped by a sheet of paper.

Radiation dose is usually measured in units of rem. Repairs to fuel-transfer systems, fuel-handling bridges, and spent-fuel pool modifications usually result in less than 1 man-rem exposure per event. Longer re-rack operations usually result in from 2 to

20 man-rem units for dive teams working in the presence of spent-fuel assemblies for periods extending to several months. However, from the standpoint of ALARA (as low as reasonably achievable) radiation exposure, man-rem exposures for divers are about 40 times lower than when doing the same job topside in the dry.

Exposures are limited by reducing the time spent near a source, increasing the distance from the source, and placing shielding between the source and the worker. The exposure to personnel is measured by personal dosimetry devices, such as the self-reading pocket dosimeter, the TLD badge, or a film badge. The federal government has standards for the amount of radiation an individual is allowed to receive in a given period of time. In some storage pools, the water temperature is over 100°F, and since the diver is wearing a dry suit there is a possibility of dangerous hyperthermia. We utilize a cool vest worn under the dry suit to circulate chilled water to the diver's torso.

GUIDELINES

Oceaneering International has guidelines for radiation protection practices for diving in contaminated water or near sources of radioactivity. The limits and precautions are: a) A valid Radiation Work Permit (RWP) should be approved before any diving operation is allowed. The RWP should specify all protective clothing requirements and diving dosimetry that are required. b) No diver is allowed to come within 20% of his current quarterly exposure limit without special permission from the station health physicist. c) A body burden analysis (BBA) is performed as required by the Health Physics Manual, and a "baseline" urine sample is taken and recorded when a diver first arrives on site (before diving) and another sample is taken before he leaves the site after completion of the diving project. d) All diving personnel must have an in-date diving medical record on file and in their dive logs. e) Individual radiation records from previous exposures are maintained in each employee's permanent personnel file. f) Training in health physics and security for each job is governed by individual client requirements. g) All personnel are familiar with all local regulations covering exposure to radiation. (10 CFR 19, Workers Rights and Responsibilities and 10 CFR 20, Exposure Limits apply to all United States Nuclear Operations.)

Due to radioactive contamination in the water, special equipment is required: a) In some cases, divers cannot exhaust bubbles that would release airborne contaminants into uncontaminated areas. Therefore, Oceaneering International can apply one of its existing technologies to solve the nuclear plant's problems, the gas reclaim hat to the surface; the "Rat Hat" diving helmet (nuclear modification) allows the diver's exhaust to return to the topside manifold. The Viking Dry Suit (nuclear, special order) has been fitted with the Oceaneering Rat Hat dry suit collar, no inflation or exhaust valves are installed on the suit, and the inside wrist sealing ring is permanently mounted to the cuff and protective gear is installed to prevent chafing. b) Other special equipment needs are a large standard diving harness, a weight belt with optical ankle weights, and at least two pairs of rubber gloves secured with electrical tape to the suit cuffs. c) The diving hose is married to a mil-spec communication wire with electrical ty-wraps. Eliminating duct tape and the rope strength member helps to reduce the fixed contamination picked up on the hose. A pneumo hose is usually not required because the depth of water in the nuclear power plant's reactor vessel or spent fuel pools rarely exceeds 40 ft. d) Main and stand-by supplies of filtered, breathable air are provided by compressor or by high pressure air banks via a volume tank and manifold. The use of in-plant air, if of breathable quality, should be investigated. e) Standard dive radios can be used, but a smaller portable belt-mounted radio is recommended. f) A safe means of entering and leaving the water is necessary. Persons entering a radiation area or contaminated area are required to wear anticontamination clothing. Divers entering the fuel storage pools are required to wear various combinations of dosimeters and alarms. Divers should wear personnel dosimetry on the head (inside and outside the helmet), chest, back, gonads, right and left thighs, ankles, hands, and arms (above the elbows). The dosimetry packages should not include the diver's normal monthly TLD or pocket dosimeter.

PROCEDURES

Dressing in and dressing out procedures must be written, a radiation survey of the pool must be completed, and the suit and helmet must be checked for leaks. Dressing in the diver can take up to an hour. Diving operations should be planned with those who will participate before beginning work. Equipment in the general area should be surveyed, including an underwater radiation survey. The plant air should be sampled after filtration (to ensure that it meets quality standards for breathing air) before using it for breathing in diving operations. In meetings with divers, it is important to ensure that before their first dive they have read and understood the requirements of the procedure, and to discuss the safety, surveillance requirements, contamination control measures to be used, the scope and duration of the planned work during the dive, and the results of the surveys. It is important to be sure that the divers dress according to the work plan.

The high pressure technician should have a telescopic dosimeter to monitor the diver when he enters the water. If the water clarity is bad, the work area is not accessible for survey from the surface, there is floating material in the water, or radiation levels are fluctuating, the diver should carry an underwater survey instrument or a detector that is capable of being read by the health physics technician at poolside or by the diver. When the diver has completed his task he is washed down with demineralized water, monitored for contamination, and dried off with clean absorbent material before he can remove his diving equipment. Remove the head dosimetry device from the diver's helmet (inside and outside) as he removes his diving equipment. When the diving operation is finished, diving equipment is surveyed, decontaminated, tagged, wrapped, discarded, or stored. The final process is to analyze body burden and urine.

EXAMPLE

All usual surface jobs can be tackled by underwater operations: cutting, welding, nondestructive testing, visual inspection, assembly or removal of mechanical structures, equipment setting or relocation, cleaning, decontamination, to name a few. The major areas in which divers have been used include spent fuel pool re-racking, various inspection and repair operations on fuel transfer systems, internals, spent-fuel pool, fuel-handling equipment, leak detection on storage tanks, and retrofit of fuel handling systems.

An example of a diving job would be to increase the capacity of the spent-fuel storage for a nuclear power station by the removal of the old contaminated, low-density racks and installation of new, high-density racks. A recent re-rack job consisted of removing 502 individual cells and supporting grid work, and installing nine free-standing, high-density racks approximately 15–20-ft high. This was approximately a threefold increase in the fuel storage capacity. The job took 7.5 mo. and required 224 dives by 5 divers, an average bottom time of 2.25 h, and an average whole-body gamma dose of 11.12 mrem per dive or 5 mrems per hour of bottom time. This particular re-rack operation utilized plasma-arc cutting (PAC) in place of conventional oxygen-arc cutting, thus reducing chemical pollution and clarity problems and increasing cutting efficiency 10-fold. Approximately 1200 linear ft of cells and grids were cut, saving approximately $250,000 in excess vacuum filters for the slag residue. Involvement during the design phases of the project enabled us to develop a lift bag which saved the power company several hundred thousand dollars in alterations and additional man hours as well as reducing safety problems by eliminating the need to remove the fuel-handling bridge to access the end of the spent-fuel pool.

With proper planning, procedures, training, and equipment, divers can perform many tasks in the nuclear industry safely and efficiently at considerable savings. Similar operational procedures, personnel, and equipment can cross over into the problems of diving in environments that involve biological and chemical hazards.