Delta-P Diving Checklist

BACKGROUND

Between June 2019 and July 2021, there were five diving fatalities that occurred at power-generation facilities as a result of *differential pressure* (*Delta-P*). At the request of the OSHA's Office of Maritime Enforcement, the Association of Diving Contractors International (ADCI) formed a task force consisting of ADCI, OSHA, contractors, the USACE, sonar experts, and facility operators to address the hazards associated with *Delta-P*.

PURPOSE

The purpose of this checklist is to provide best industry practices in a clear and complete format for dive operations at power-generating facilities where *Delta-P* hazards exist. It is a guide for those responsible for creating Dive Procedures and Job Hazard Analysis (*JHA*). It consists of three sections:

- A checklist for planning and execution when diving in areas with potential for *Delta-P*.
- A list of relevant terminology useful in the discussion of *Delta-P.*
- A list of resources for planning *Delta-P* diving operations.

The unclogging of drains is specifically not covered. Such operations require situationally specific *barriers* and *controls* and should be undertaken only with thoroughly engineered plans and as a last resort.

This checklist should not be considered an all-encompassing source for those planning *Delta-P* diving operations. It is intended to raise a level of awareness of *Delta-P* hazards at power-generating facilities and invite further research with the sources provided.

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NOTE: No responsibility is assumed by the task force members involved in the writing of this document for any injury and/or damage to persons or property as a matter of liability, negligence or otherwise, or from any use or operation of any methods, product, instruction, standards, rules or ideas contained herein. No suggested test or procedure should be carried out unless, in the reader's judgment, its risk is justified, and the reader assumes all responsibility.

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Plan the Dive	Initials	Date
1. Plan the scope of work considering *Delta-P* hazards. Consider alternatives to diving and use remote sensing methods when possible (i.e., remotely operated vehicle (ROV) or *sonar imaging* methods). Use findings to evaluate conditions and reduce divers' exposure to *Delta-P* hazards when possible.		
2. Notify all plant personnel of the exact date and time ranges of diving operations.		
3. Identify, by position and name, the designated facility person (with sufficient technical and supervisory authority) for normal and emergency contacts. Request a facility person with direct authority to be onsite at all times.		
4. Write a dive plan based on the scope of work and Job Hazard Analysis (*JHA)*. The dive plan must include a prioritized mitigation plan specific for each *Delta-P* hazard, an emergency action plan, and an *umbilical management* plan.		
a. Mitigation Plan		
i. Review plans, blueprints, photos, surveys, and/or as-built drawings with the appropriate plant competent people to understand the layout, geometry, and operation of the facility or structure.		
ii. With plant representative, locate and document all *Delta-P* hazards. Some examples include: pumps, including ones that run intermittently such as fire pumps; flow *control* openings such as sluice gates, stop logs and valves; bar screens or traveling water screens; dams; locks; water tanks; cofferdams; pipeline penetrations; etc.		
iii. Calculate the *capture zone* of the known hazards and specify minimum safe distance to be maintained from those areas by the diver and the diver's umbilical (see references 1, 3, 4, 5, and 6 for calculation methods).		
iv. Plan the work for when the maximum number of *Delta-P* sources can be eliminated (i.e., pumps secured, valves isolated, etc.). Note: If a plant suggests that a pump or intake cannot be secured, require a written plan for plant procedures if an umbilical or diver becomes entangled in the pump.		
v. Develop a site-specific Lockout-Tagout (LOTO) plan with the facility and all concerned parties. Address items such as: personal locks where applicable, physical verification where possible, and setting of plant clearance boundaries.		
vi. Determine Confined Space applicability and hazard *control* measures including permit required confined space entry protocols as required for topside personnel.		
vii. Develop a plan to install physical *barriers* if possible.		
viii. Develop a method to verify no-flow conditions, such as: use of *tell-tales*, flowmeters, an ROV), *sonar imaging*, observation of downstream water flow, etc.		
b. Emergency Response Plan		
i. Create an emergency response communication tree and process to inform facility personnel as well as onsite and offsite emergency personnel in the event of an incident.		

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ii. Identify available first aid and basic life support personnel available for emergency operations.		
iii. Using information identified in the dive safety plan, establish a written *Go / No-Go* and Emergency Termination criteria for the operation.		
iv. List dive and support personnel actions in the event of an emergency situation. (Key actions per team member role.)		
v. Outline emergency stop procedures for operations and equipment required for water extractions if feasible.		
vi. Determine actions and equipment required within the scope of the team's training.		
vii. Identify worst-case recovery actions and personnel required.		
viii. Define rescue/recovery assets that may be needed.		
c. Umbilical Management Plan		
i. Determine the best location to tend the diver to minimize exposure to entanglement and entering the *capture zone*.		
ii. Plan the travel path of the diver and umbilical relative to physical structures. Identify and map distinct physical features of the work area to assist the diver in identifying their position relative to *differential pressure* sources.		
iii. The necessary length of umbilical should be secured so that more than that length cannot be fed into the water. The umbilical should be physically restrained or have *barriers* installed to be prevented from reaching any unmitigated *Delta-P capture zones*.		
iv. Develop a method to communicate and track diver movements in real time.		
v. Determine if *sonar imaging* is appropriate to monitor diver and/or umbilical via qualified personnel.		

Pre-Dive	**Initials**	**Date**
1. Conduct a pre-dive briefing with the dive team, plant personnel and any other stakeholders. Outline *Go / No-Go* criteria for the dive operation.		
2. With plant representatives, verify the mitigation plan for each *Delta-P* hazard.		
a. Verify *capture zone* calculations and minimum safe distances with plant engineers.		
b. Verify the work is being conducted when the maximum number of *Delta-P* sources can be eliminated (i.e., pumps secured, valves isolated, etc.) as planned.		
c. Execute hazardous energy work boundary processes, such as Lockout-Tagout or clearances.		
d. Execute permit required confined space entry protocols as planned for topside personnel.		
e. Prepare physical *barriers* if applicable.		
f. Verify no-flow conditions through use of: *tell-tales*, flowmeters, an ROV, *sonar imaging*, observation of downstream water flow, or etc.		

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3. When possible, use *sonar imaging* methods to locate possible unknown *DP* hazards and inspect the areas prior to diving. Note: If any additional and/or new risks are identified then update the applicable sections of the dive safety plan and integrate into the pre-dive training briefing.		
4. Conduct *Just-in-Time* topside dry training / mock dive to include: the actual work procedure, the *umbilical management* plan, *three-way communication*, emergency response actions, and each member's role.		
5. Ensure *domain awareness*. All dive team members must understand the physical form of the structure, how the plant systems work together and where the *DP* hazards are including the *capture zones*.		
6. Test communications between the dive station and plant operations and EMS.		
7. Conduct an Emergency Response Plan briefing prior to initiating dive operations.		
8. Ensure the umbilicals are secured.		

Dive Operations	**Initials**	**Date**
1. Slowly deploy the diver down a ladder or via a stage. The diver must be extremely aware his/her domain. Report all water movement at the water entry point to the supervisor.		
2. Divers will continuously communicate all movements using *three-way communication* with topside and be tracked by monitoring umbilical length and communication with the diver and/or using *sonar imaging*.		
3. Continuously tend all divers and *fish the diver*. Avoid slack in diver's umbilical. Diver will verbally ask for slack (or ask for slack to be taken up) using *three-way communication*.		
4. Implement measures to ensure diver is unable to reach the *Delta-P* hazards. This can be done by flagging or tying of the umbilical topside, or installing physical *barriers* as applicable.		
5. When the work site is reached, the diver will report the water flow to the supervisor. Report any change immediately. If conditions are not as planned or change during the dive, bring the diver to the surface and reevaluate the plan.		
6. Begin the work only after the work area is deemed safe by the diver and diving supervisor.		
7. Supervisor ensures that dive team maintains *situational awareness* throughout the diving evolution.		

Post-Dive	**Initials**	**Date**
1. Modify the dive plan, work area map, and *JHA* to reflect lessons learned.		
2. Archive all plans, maps and *JHA*'s for future reference.		

RELEVANT TERMINOLOGY

Barrier: Any physical control used to prevent the diver, diver's umbilical, or equipment from being entrapped by differential pressure.

Capture zone: The immediate area surrounding a differential pressure source that a diver or a diver's umbilical would not be able to escape. Sometimes referred to as an exclusion zone or danger zone.

Control: Any action taken to mitigate hazards to the diver.

Differential Pressure, Delta-P,* or *DP: The difference in pressure between any two points in an open or closed system which can result in fluid flow creating a hazard for a diver.

Domain Awareness: Understanding how domains operate and interact within their environment and how they could impact safety.

Fish the diver: Holding the diver's slack tight enough to feel him without restraining his movements. The tender should feel his movements in his fingers. This ensures the minimal amount of slack is always in the water limiting the possibility of it drifting into a *DP* Source or becoming entangled.

Go / No-Go: Criteria identified by both the dive team and the plant facility which is used to determine if a dive is conducted or not.

JHA: Job Hazard Analysis. An analysis of the hazards and risk associated which focus on identifying and controlling hazards.

Just-in-Time: Training conducted on the site to cover important site safety aspects just prior to the start of the job.

Sonar imaging: Sound returns sent through the water are measured and plotted to image underwater conditions. Various systems exist with a wide range of names. Site specific conditions will usually determine the best systems to provide the most reliable and clear images of conditions required.

Situational Awareness: Each worker must be aware of what is happening around them in terms of where they are, where they are supposed to be, and where anyone or anything around them is a threat to their safety.

Tell-tale: A device or object that automatically gives a visual indication of the state or presence of differential pressure. String mop head, lines, or ribbons on poles are examples of diver-held tell-tales.

Three-Way Communication: The sender (worker) states the message, the receiver (another worker) acknowledges the sender and repeats the message in a paraphrased form, and the sender acknowledges the receiver's reply is correct. Sometimes called three-part or repeat back communication.

Umbilical management: Procedures or physical controls to limit the umbilical and diver to areas free of differential pressure sources.

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