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No. 1110-2-6071

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Engineering and Design
REMOTE CONTROL AND OPERATION OF WATER CONTROL SYSTEMS

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
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REMOTE CONTROL AND OPERATION OF WATER CONTROL SYSTEMS

1. Purpose. The purpose of this circular is to establish policy for the implementation and operation of remotely operated, remotely controlled, and automatically operated water control systems owned or operated by USACE.
2. Applicability. This circular applies to all USACE/OCE elements and field operating activities having Civil Works responsibilities. This circular does not apply to hydropower generation control systems which are covered by other policy documents.
3. References.
 - a. ER 1110-2-240, Water Control Management, 8 October 1982
 - b. ER 1110-2-8, Preparation of Water Control Manuals, 31 August 1995
 - c. ER 1110-2-8157, Responsibility for Hydraulic Steel Structures, 31 January 1997
 - d. ER 11110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
 - e. USACE Draft ER 1110-2-1156, Safety of Dams – Policy and Procedures, April 2010
 - f. USACE EP 310-1-6a Volume 1, Sign Standards Manual, 1 June 2006
 - g. DoD Instruction Number 8510.01, Subject: DoD Information Assurance Certification and Accreditation Process (DIACAP), November 2007
 - h. DoD Instruction Number 8500.2, Subject: Information Assurance Implementation, February 2003
 - i. USACE Baseline Security Posture Guide for Civil Works Projects – December 10, 2004
 - j. Guidelines for Public Safety at Hydropower Projects, Federal Energy Regulatory Commission, March 1992
 - k. Federal Guidelines for Dam Safety – Glossary of Terms, Federal Emergency Management Agency (FEMA 148), April 2004

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l. Federal Guidelines for Dam Safety, Federal Emergency Management Agency (FEMA 93), April 2004.

m. Federal Guidelines for Dam Safety – Emergency Action Planning for Dam Owners (FEMA 64), April 2004.

4. Distribution. Approved for public release; distribution is unlimited.

5. Definitions.

a. Automatically Operated System: Operation is determined and made by automated means based on instrumentation data without requiring direct input from personnel.

b. Locally Controlled System: Operation is made by personnel physically located at the project site using controls that are physically located at the structure being operated.

c. Remotely Controlled System: Operation is made by personnel who are physically located at the project site using remote controls that are not physically located at the structure being operated.

d. Remotely Operated System: Operation is made by personnel who are not physically located at the project site using remote controls that are not physically located at the structure being operated.

e. Spillway: A structure over or through which flow is discharged from a reservoir. If the rate of flow can be controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

f. Water Control System: Any structure or group of structures and its appurtenant components that is used as part of a system to control or modify the conveyance of water such as gates, pumps, valves, motors, controls, power supply, etc.

g. Failure: Any condition that results in the uncontrolled release or discharge of water. For purposes of this regulation, this might include misoperation involving improper or unintended opening or closing of gates, pumps, valves, etc. Misoperation leading to systems not operating when needed or intended (i.e. gates fail to open on demand) might also lead to failure. Another example could be structural failure involving partial or total collapse of a gate.

h. Interlock: A device for preventing a mechanism from being set in motion when another mechanism is in such a position that the two operating simultaneously might produce undesirable results.

6. Discussion.

a. Operation of water control systems can be accomplished in various forms. The U.S. Army Corps of Engineers (USACE) has installed remotely controlled and remotely operated systems to operate tainter gates, sluice gates, and valves on flood risk management, hydropower, and navigation projects throughout the nation. The concept of remote control is that a water control system can be operated from an on site project office by on site personnel without requiring the operator to physically move to and from the structure for local operation. This approach can improve the efficiency of operations and potentially reduce staffing requirements. The concept of remote operation is that a water control system can be operated from an offsite office location by offsite personnel without requiring the operator to physically travel to the site for local operation. This approach can also improve the efficiency of operations and reduce staffing requirements. The remote method of operation could allow one person to operate multiple water control systems at different projects from a single location. The remote operation location can be a regional project office, District office, or other appropriate facility depending on the distance from the project site. The concept of automatic operation is that a water control system can be operated without any direct input from personnel. The system uses automated instrumentation data to make operational decisions based on a pre-defined set of decision criteria. An example of an automatic operation could be a pump station that uses floats to automatically activate the pumps when required.

b. Any decision on how to operate a water control system must be carefully considered to ensure safe operation of the project and adequate protection of the public, property, and environment. The cost saving benefits derived from reduced staffing requirements must be balanced with the potential increased risk associated with an unstaffed project.

c. As owners and operators of projects with water control systems, USACE considers public safety to be paramount. Potential risks must be evaluated to ensure that water control systems are robust and processes are established to validate systems are in good working order. In some cases, mitigation and/or contingency measures are required to reduce the likelihood of a system failure that could result in an uncontrolled reservoir release. Additionally, spillway systems must be regularly maintained, inspected and tested to ensure functionality at all times.

7. Eligibility of Water Control Systems.

a. Automatically operated systems shall not be used for water control systems when misoperation or failure of the system could result in life loss, property damage, environmental impact, or lifeline disruption. In cases where property and environmental losses would be limited to the project site, automatically operated systems may be considered.

b. Remotely operated systems shall not be used for water control systems when misoperation or failure of the water control system could result in loss of life.

c. Remotely controlled, remotely operated, or automatically operated systems shall not be used for water control systems involving hydraulic steel structures unless all applicable requirements for design, inspection, and evaluation have been accomplished in accordance with ER 1110-2-8157.

d. Remotely operated or automatically operated systems shall not be used for dams with a Dam Safety Action Classification of DSAC I or DSAC II.

e. Remotely controlled, remotely operated, or automatically operated systems shall not be used for water control systems on projects requiring a water control plan unless the water control plan meets the requirements of ER 1110-2-240.

f. Remotely controlled, remotely operated, or automatically operated systems shall not be used for water control systems that require an emergency action plan unless the plan is current and an exercise has been conducted commensurate with the projects DSAC.

g. For projects with existing remotely controlled, remotely operated, or automatically operated water control systems, a plan shall be developed to implement the requirements of this regulation. The plan and timeline for implementation shall be approved in accordance with the requirements of paragraph 13 of this regulation.

8. Water Control System Considerations and Requirements. Best practices outlined the following sub paragraphs shall be considered and implemented as appropriate at each project for each remotely controlled, remotely operated, and automatically operated water control system. Additional considerations and requirements shall be developed as appropriate to address site specific conditions.

a. Redundancy. Appropriate redundancy shall be provided for all water control systems. At a minimum, redundancy shall be provided for communication, warning issuance, upstream and downstream water level readings, and gate opening information. In addition, all water control systems shall maintain capability to be operated locally with appropriate interlocks.

b. Public Safety and Warning. Restricted zones upstream and downstream of the project shall be established and enforced where appropriate. Visual and audible warnings shall be provided at appropriate locations upstream and downstream of the facility to notify the public prior to making any operation that could pose a hazard to the public. Operations requiring public warning would typically only include those that increase discharge releases (i.e. opening gates, turning on pumps, etc), but might include other types of operation depending on site specific conditions. A visual warning such as a flashing light shall be provided along with an audible siren or horn. The warning issuance should be confirmed by the operator prior to operating the system. For remote operation, this would typically require a microphone and/or camera system for visual and audible confirmation. For remote control, confirmation requirements would depend on the proximity of the operator and the ability to hear and/or see the alarm. For automatic operation, the system should have capability to automatically confirm the warning. An interlock system should be provided to prevent operation of the system if the audible warning is not confirmed. Appropriate warning signs shall be provided to notify the public of the type of operation and potential for changes in discharge due to operation. Signs should conform to EP 310-1-6a, Volume 1. Additional warning considerations can be obtained from "Guidelines for Public Safety at Hydropower Projects" (FERC). Considerations in this reference document are not necessarily limited only to hydropower projects.

c. Personnel Safety and Warning. Visual and audible warnings shall be provided at appropriate locations on the project itself to notify project personnel prior to making any operation that could pose a hazard to the project personnel. Operations requiring personnel warning would typically include those involving movement of machinery and parts that could create and entrapment or similar hazard. A visual warning such as a flashing light shall be provide along with an audible siren or alarm. The warning should be visible and audible to the operator for confirmation of the warning. For remote operation, this would typically require a microphone and/or camera system. For remote control, confirmation requirements would depend on the proximity of the operator and the ability to hear and/or see the alarm. For automatic operation, the system should have capability to automatically confirm the warning. An interlock system should be provided to prevent operation of the system if the warning is not confirmed. The interlock system should also provide capability for onsite personnel to disable the remote or automatic operations when performing gate maintenance or other similar activities.

d. Incremental Operation. Appropriate controls and interlocks shall be provided to limit the rate of change and maximum change in discharge releases with each operation to an acceptable level. Acceptable level is considered that which would not endanger project personnel or the public. The appropriate rate of change and maximum change will be site specific and should be determined for each water control system.

e. Confirmation. Prior to operating a water control system, the operator shall visually inspect by personal observation and remote camera viewing the following: gate opening, downstream gage, personnel in gate and/or discharge areas.

f. Training. Operators shall attend appropriate training for both local and remote operation of all controls and warning systems at the facility. Refresher training shall be provided on an annual basis.

g. Staffing for Routine Operation. Adequate staffing must be available to conduct routine onsite inspection and maintenance activities in accordance with the project O&M manual and any other similar requirements. The frequency and level of routine maintenance and inspection should be appropriate for the needs of the project and not be reduced solely based on a decision to remotely operate.

h. Staffing for Non-Routine Operation. Adequate staffing must be available to conduct non-routine operation, inspection, and maintenance activities. These might include flood surcharge operation, deviations from the approved water control plan due to drought or other emergency, or emergency inspection and/or repairs due to an incident. The distance and time required for personnel to reach the site for non-routine operation should be a consideration when developing plans to remotely operate. During extreme flood events, roads may be inundated and transportation to the project may be interrupted. Alternate methods may be necessary, such as use of helicopters, especially for emergency surveillance of the project. The capability to remotely operate shall not be used as a basis to postpone on-site emergency surveillance. The ability for personnel to access the project site should also be considered (e.g. can the site be accessed during flood conditions or are the access roads flooded). The number of personnel required to staff multiple projects at the same time during a large scale event (e.g. system wide flood) should be considered and addressed.

i. **Emergency Response Time.** The ability to quickly respond to emergency conditions shall be considered when developing plans to remotely operate. Remote operation should not be performed when a foreseeable issue could lead to partial or total failure before an emergency response team could be deployed to the site to intervene. A potential failure mode analysis is recommended to assist with the identification of such issues.

j. **Emergency Action Plan.** If required, the emergency action plan for the project shall be updated to reflect appropriate changes due to remote control, remote operation, or automatic operation.

k. **Operation and Maintenance.** The project operation and maintenance manual and drawings shall be updated to reflect changes in the water control system and operating features.

l. **Monitoring and Inspection.** Required monitoring and inspection shall continue at the project regardless of the mode of operation. This includes both routine and non-routine activities. Additional monitoring and inspection requirements shall be considered as appropriate for all remote control, remote operation, or automatic operation to ensure safe operation.

m. **Hydraulic Capacity.** The capacity of the downstream channel should be considered when developing a plan for remotely or automatically operate. If capacity of the water control system exceeds the downstream channel capacity, then additional warning systems and safety measures may be appropriate. In some cases, these conditions might be a basis for a decision to not allow remote or automatic operation of a particular water control system.

n. **Diagnostics and Feedback.** Appropriate features should be provided to inform the operator of the overall health of the operating system and diagnose system problems. Appropriate diagnostic and feedback systems should be provided to identify and resolve issues in a safe and timely manner.

9. Other Requirements.

a. **Dam Safety.** A risk informed decision making process shall be used when making a decision to remotely or automatically operate a water control system. Some key factors to consider include the Dam Safety Action Classification (DSAC) for the project, redundancy and resiliency of the water control system, discharge capacity, storage capacity, freeboard, type of dam, known dam safety issues, potential failure modes, and downstream consequences. Provisions need to be made to satisfy both routine and non-routine dam safety related inspections and activities. A potential failure mode analysis is required to identify issues related to misoperation or failure that could lead to loss of life, property damage, environmental damage, or lifeline losses.

b. **Security.** There are three primary elements of a water control system that must be protected. These features are communications, software, and physical equipment. In order to remotely control or remotely operate a water control system, communication to and from the project site is required. This communication system must be DoD Information Assurance Certification and Accreditation Process (DIACAP) certified and shall follow the Information Assurance Implementation guidance. The system includes the equipment on the water control

system and the computers and communication lines that are used to access the system. The equipment on the water control system shall be adequately protected by following routine security measures.

c. Water Management.

(1) Remotely controlled, remotely operated, or automatically operated water control systems shall not modify the project regulation schedule containing the operating criteria, guidelines, rule curves, and specifications that govern the authorized storage and/or discharge functions of the project without updating the water control plan.

(2) Modification of the operating equipment or procedures at a project to implement remotely operated or automatically operated water control systems are considered to be a change to the water control plan which requires a water control manual update and public coordination in accordance with ER 1110-2-240. Significant changes to existing remotely operated or automatically operated water control systems shall also be considered a change to the water control plan.

(3) Minor changes (e.g replacement or upgrade with similar equipment) to existing remotely operated or automatically operated water control systems do not constitute a change to the water control plan and should be addressed during routine water control manual updates following ER 1110-2-8156. Modification of the operating equipment or procedures at a project involving remotely controlled water control systems does not constitute a change to the water control plan and should be addressed during routine water control manual updates following ER 1110-2-8156.

10. Procedures.

a. Routine Operation. Routine operations may be made using remote control, remote operation, or automatic operation systems in accordance with the project O&M and water control manuals. A typical routine operation procedure is illustrated below.

(1) Log in to remote control software.

(2) View cameras upstream and downstream to look for people, debris, or possible hazards.

(3) Check current level of gate to be operated by looking at the inclinometer or position indicator readings. If gate is off sill and the two inclinometers have a significant difference the interlock system will not allow this gate to be moved. At this point someone should be sent to the project site to assess the situation and to recalibrate the inclinometers if required.

(4) Sound siren for prescribed amount of time. If applicable, listen to speakers to audibly confirm the siren.

(5) View cameras upstream and downstream to look for people, debris, or other possible hazards.

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(6) Use remote control system to move the gate to the desired height. This may take several operations to move past the set increments.

(7) View cameras upstream to look for people, debris, or other possible hazards. View cameras downstream to look for hazards and confirm flows.

(8) Once the gate is at the desired height the user shall verify proper downstream flow and re-adjust if necessary.

b. Non-Routine Operation.

(1) Flood. Local or remote control operations are required for induced surcharge operation during significant flood events. Remote operation or automatic operations are not permitted under these conditions.

(2) Ice and/or Debris Passage. Local or remote control operations are required for passage of ice and debris. Remote operation or automatic operations are not permitted under these conditions.

(3) Emergencies. Local or remote control operations are required for emergency operations. Remote operation or automatic operations are not permitted under these conditions.

11. Maintenance.

a. Inspection. Appropriate inspection frequency and procedures shall be established for all remotely controlled, remotely operated, and automatically operated systems. The procedures shall be formally documented in the project O&M manual and other appropriate project documents.

b. Testing. Appropriate testing frequency and procedures shall be established for all remotely controlled, remotely operated, and automatically operated systems. The procedures shall be formally documented in the project O&M manual and other appropriate project documents.

c. Recurring Maintenance. Required maintenance is categorized as “as needed maintenance” and “preventative maintenance”.

(1) The as needed maintenance might include:

- (a) Cleaning the camera housings and lenses.
 - (b) System reboots.
 - (c) Repair, if and when failures of equipment occur.
 - (d) Calibrating the sensors.
- (2) The preventative maintenance might include:
- (a) Visually inspecting all remote equipment. This includes cameras, housings, sensors, servers, exposed communication lines and conduits.
 - (b) Cleaning all components of the system, including camera housings.
 - (c) Providing and installing, upon verification of proper operation on an offline test computer and in accordance with the DIACAP certification, any software upgrades that are necessary.
 - (d) Providing and installing any hardware upgrades that are necessary.
 - (e) Testing each component of the system by following the standard operating procedures.
 - (f) Repairing or replacing any damaged, worn, or failed equipment.
 - (g) Keeping written documentation stating every action taken.
- (3) The installation and operation of remote control equipment will not change the required maintenance for the electrical and mechanical hoist equipment.
- d. Replacement. All equipment has a finite lifespan. The maintenance and upgrades include replacing any failed equipment, monitoring equipment to find possible failures before they occur, and upgrading any equipment that is obsolete or worn. Equipment is recommended to be scheduled for upgrade or replacement as follows:
- (1) Controller Computers – 3 year cycle,
 - (2) Monitors – 6 year cycle.
 - (3) Cameras – 3 to 5 year cycle or as needed.
 - (4) Sensors – As needed.
 - (5) Control Devices – As needed.
12. Approval Authority. Approval authority may not be delegated below the level prescribed by the following sub paragraphs.

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a. Remote Control. The District Commander shall approve decisions to remotely control water control systems.

b. Remote Operation. The MSC Commander shall approve decisions to remotely operate water control systems.

c. Automatic Operation. The MSC Commander shall approve decisions to automatically operate water control systems.

FOR THE COMMANDER

A handwritten signature in black ink, appearing to read 'J. Dalton', with a long horizontal line extending to the right.

JAMES C. DALTON, P.E
Chief, Engineering and Construction
Directorate of Civil Works