

**Appendix L**  
**DETAILED RADIAL GATE INSPECTION REPORTS**

## BACKGROUND AND PURPOSE

The FERC Tainter Gate Initiative (TGI) was implemented in 1998 following the forensic investigation into the failure of a radial spillway gate at Folsom Dam. The purpose of the TGI was to ensure that there would be periodic review of the design assumptions and up-close inspections of radial gates at FERC-regulated projects.

Since the 2001 revision to the initiative, each dam with a **Category 1 radial gate**<sup>1</sup> has been required to submit a detailed **Gate Inspection Report (GIR)** at a ten-year interval. The GIRs submitted have varied in quality, scope, and contents; the purpose of this document is to provide guidance on our minimum expectations for the GIRs.

While this guidance specifically addresses radial gates subject to inspections under the TGI, the FERC recognizes that many dams have other types of gates that could have dam safety, operational, or life safety consequences in the event of failure or misoperation. If the D2SI-Regional Engineer (RE) determines that a gate or set of gates meets the conditions to be classified as a Category 1 gate, and requires detailed “hands-on” inspections, the guidance herein shall apply regardless of the gate type.

## RADIAL GATE INSPECTION REPORTS

### Submittal Procedures

A GIR should be submitted every ten years, or more frequently if determined to be necessary by the RE. If any conditions are identified during the gate inspection that could reasonably be considered to constitute a dam safety issue, the licensee should immediately report it to the RE in accordance with 18CFR §12.10 (a).

A GIR transmittal letter should be addressed to the RE and should include:

- A summary of the key findings of the GIR;
- A summary of key findings of the previous GIR and any work (e.g., analysis, maintenance, or modifications) performed in the interim;
- A clear statement by the Chief Dam Safety Engineer or Coordinator (CDSE) that they have reviewed the GIR, concur with its findings, or adequate justification and rationale for any ‘non-concurrence’; and
- A list of recommendations, as appropriate, for routine maintenance, investigation, or major remediation, as well as the CDSE’s plan and schedule for addressing those items.

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<sup>1</sup> A Category 1 gate is defined as one for which either of the following is true:

- 1) A structural failure of the gate, or the gate’s inability to open or close, endangers downstream life during normal operations or flood events; or
- 2) A failure to open or close results in a significant uncontrolled reservoir level rise or drop during normal operations or flood events, affecting upstream life, property, or resources.

The report should be submitted to the appropriate Regional Office per the procedures shown in the FERC Filing Guide (<http://www.ferc.gov/docs-filing/forms/fileguide.pdf>). The report should be securely bound and each copy should include a DVD containing a searchable electronic version of the report, including appendices. Appendices D and E may be included in electronic format only, if desired.

## **Outline of the Gate Inspection Report**

The GIR should be organized into the following sections:

1. Inspection Scope
2. Review of Existing Documentation
3. Inspection Findings
  - 3.1. Gate No. 1
  - 3.2. Gate No. 2
  - 3.3. Gate No. 3... [etc.]
4. Recommendations
5. Conclusions

Appendices

Appendix A: Inspection Team Resumes

Appendix B: Status of Previous Recommendations

Appendix C: Drawings and Schematics

Appendix D: Inspection Photos (DVD only)

Appendix E: Inspection Field Notes (DVD only)

## **Contents of the Gate Inspection Report**

### ***Inspection Scope***

This section should include the following:

- The Scope of Work for the gate inspection;
- The general qualifications and experience of the inspectors, with a reference to their resumes (Appendix A); and
- The name of the lead engineer on the team – each team should include at least one engineer qualified to review and comment on the adequacy of the spillway gate analysis of record; and
- A statement of independence – if the inspection is performed by a party other than the licensee, include a statement declaring that the inspection findings, conclusions, and recommendations were made independent of the licensee and its employees.

### ***Review of Existing Documentation***

This section of the report should contain a summary of existing documentation, including gate analyses, licensee procedures, operational history, and prior GIRs. Any other information important to the design, operation, and performance of the gates should be included, including any modifications to the design or operation of the gates. Additional guidance for what to include in this section of the GIR is described below.

*Gate Analysis:* The inspection team should review the analysis of record and comment on the assumptions (including material properties), methods, and results. If the gate analysis is obsolete, incorrect, or does not exist, the inspection team should immediately contact the CDSE, who should coordinate with the D2SI-Regional Office to establish a schedule for completing a new analysis. This section should include a summary of the load cases, material properties, and other pertinent design basis information.

Structural members and connections should be identified as either critical or non-critical, based on the analysis results. The failure of a critical member would be expected to result in either an uncontrolled release of the reservoir or failure of the gate to operate as designed.

*Licensee Procedures:* Review and comment on the licensee's procedures for inspection and maintenance (including lubrication, if required) of the gates, hoist equipment, power sources, control systems, and cables that comprise the power and SCADA systems. Attention should be given to discussion of the trunnions, including the manufacturer, installation date, physical properties, and lubrication requirements.

*Operational History:* Provide a brief list of significant operational issues during the life of the gates. For example, misoperation and racking due to chain binding, or dropping of a gate due to a hoist failure, should be discussed. The annual spillway gate certificates should be reviewed and the team should comment on any apparent trends, unusual amperage readings, and power draw in excess of the rated capacity of the motors.

*Prior GIR:* Provide an update on recommendations from the prior GIR. Critical recommendations should be discussed in this section; general maintenance items may be mentioned as necessary or simply included in the table in Appendix B.

### ***Inspection Findings***

Each radial gate should be discussed individually. The GIR should include clear, definitive statements about the condition of structural members and connecting elements, with an emphasis on those designated as critical based on the review of the analysis. Photos should be provided for significant observations. It is not necessary to include every photo in the body of the GIR, though all photos should be included on the companion DVD.

This section of the report should be presented in an appropriate format (e.g., paragraph, tabular, or diagrams) that clearly conveys the observations. Photos should be used to help explain any conditions noted. The following items should be addressed in the GIR (this is not an exhaustive list):

- Bent, deformed, or missing members or connecting elements;
- Weld defects: identify any instances of cracking, problematic details, or visibly poor weld quality;
- Mechanical fasteners: bolts and rivets should be compared to the information shown on the drawings. Loose fasteners, those visibly cracking or deformed, and those that do not conform to the record drawings, should be identified;
- Corrosion protection: discuss the condition of the coating system and whether there is a need for repair. If there is a cathodic protection system, indicate whether it is well-maintained, functional, and installed correctly;
- Corrosion: provide clear indication of the type of corrosion (e.g., surface, pitting, etc.), the location and percent of the member affected, and whether it may have structural implications;
- Drainage and debris: identify the location of any ponding water and discuss whether drainage should be provided. Accumulation of debris, including excessive animal waste, should be discussed;
- Seal condition and serviceability (including side, bottom, and top seals, as applicable);
- Lifting devices and attachments (including cables, chains, eyebolts, clevises, sheaves, etc.); and
- Mechanical and electrical components of the hoist equipment.

Operation Test: The inspection team should observe each gate moving through its full range of motion, fully closed to fully open and back, and provide observations and comments. If the requirement for a full open test does not coincide with the year of the GIR, it is acceptable for the GIR to include a review and comments on the previous full open testing, provided there is sufficient documentation available from that test for the inspection team to make an informed conclusion regarding the operational condition of the gate (e.g., real-time power draw plots, video with audio, etc.).

### ***Recommendations***

The GIR should include recommendations for how any and all identified deficiencies should be addressed. Recommendations should be flagged according to the importance of the issue. For example, categories could be:

- *Critical, dam safety-related*
- *Potential dam safety issue requiring investigation*
- *General maintenance*

### ***Conclusions***

The inspection team should provide an overall conclusion regarding the fitness of the gates for continued safe and reliable operation. The discussion should include an assessment of how the overall condition of each gate has changed since the previous GIR.

## **Appendices for the GIR**

Appendix A: Inspection Team Resumes. Include resumes of the inspection team, including the qualified engineer who reviewed the prior gate analysis. That individual should either be a licensed Structural Engineer or have sufficient work experience to demonstrate a comprehensive understanding of issues associated with radial gates.

Appendix B: Status of Previous Recommendations. The status of previous recommendations should be updated in a tabular format. Critical recommendations are to be discussed in detail in the body of the report.

Appendix C: Drawings and Schematics. The drawings and schematics included in this section should convey all required information about the structural members and connecting elements of the gate, anchorage, and hoist equipment. As-built drawings and any drawings depicting significant modifications since original construction are recommended. Drawings should be printed at 11x17 inches and should be clear and legible to the unaided eye.

Appendix D: Inspection Photos (DVD only). If desired, this appendix may be included only electronically and not in hard copy. All inspection photos should be included at full resolution and in folders organized by gate number.

Appendix E: Inspection Field Notes (DVD only). The inspection team field notes should be scanned and included for reference. If desired, this appendix may be included only electronically and not in hard copy.

## **Previous FERC Letters Regarding Radial Gates**

Refer to the following pages.

**Original Tainter Gate Initiative (1998)**

**Federal Energy Regulatory Commission**

**Chicago Regional Office  
230 South Dearborn Street, Room 3130  
Chicago, Illinois 60604**

February 24, 1998

In reply  
refer to: 02161

Mr. Al K. Davis  
Vice President of Engineering  
Wausau Papers  
515 West Davenport Street, P. O. Box 100  
Rhineland, WI 54501

Dear Mr. Davis:

This letter is to inform you that as a result of the findings of the Bureau of Reclamation as to the cause of the 1995 Folsom dam tainter gate failure, the FERC will require a review of the design criteria, inspection, maintenance, and lubrication procedures for all tainter gates (radial gates) at high and significant hazard potential dams. While we are limiting our review to only high and significant hazard potential projects, we recommend that a similar review be conducted for your low hazard projects as well.

The Bureau of Reclamation has released a forensic report on the failure of the tainter gate at Folsom dam in 1995. The failure report entitled "Forensic Report on the Spillway Gate 3 Failure, Folsom Dam" concluded that the cause of the tainter gate failure was as follows:

Corrosion on the loaded side of the steel trunnion pins increased trunnion friction over time. Trunnion friction, which was not considered in the design of the gate, induced bending moment loads in the gate struts (radial arms), which were resisted principally by the diagonal strut braces. The failure occurred when the strut brace loads caused by the increased trunnion friction exceeded the strut brace connection bolt capacity.

The effort will consist of the following:

- A. Conduct a general review of the design of your tainter gates to insure that nothing was overlooked in the design and construction of the gates. Specifically, you should review the design of your tainter gate strut arms to determine if forces and moments due to trunnion friction were considered. If no information is available, this should be stated.
- B. Documentation should be developed covering your trunnion lubrication procedures including frequency and type of lubricant used as well as experiences associated with different lubricants. Also, other regular maintenance activities such as painting, seal replacement, etc, shall be covered.

Your findings from items A and B shall be submitted to the Chicago Regional Office within 60 days of receipt of this letter.

- C. For all tainter gates, amperage draw and line to line voltage should be measured while lifting the gate under full head. These measurements should be done in conjunction with the annual gate tests currently required and included with the annual gate test certification. You should verify that the values recorded are less than or equal to the motor nameplate values. This information will be reviewed and discussed during the FERC annual operation inspection.
- D. The adequacy of your gate design shall be verified by your next Part 12 consultant. As part of your next Part 12 independent consultant's report, your consultant should do the following:
  - 1) Carefully inspect each gate including all structural members and trunnions, and specifically address the findings of this inspection in the Part 12D report.
  - 2) Show that forces and moments due to trunnion friction can be sustained with a temporary over stress allowance of 1.33 on the steel strength. In the absence of a measured value, a friction coefficient of 0.3 shall be assumed with the gate under full hydrostatic pressure. If calculations indicate that the gate can not sustain this load case, remedial measures shall be proposed.



- 3) Comment on the appropriateness of your lubrication procedures as well as other maintenance activities.
- 4) Comment on the records of amperage draw and line to line voltage that you will have compiled. Specifically, your consultant shall compare the rated horsepower with these recorded values. This will give an indication of the reserve capacity available in the lifting machinery and allow the opening resistance of a gate to be compared with respect to time and other gates.

For those significant hazard potential projects which are not required to submit a Part 12D, Independent Consultant Inspection Report, you will have to perform an analysis of the design of the tainter gates (items 1-4 above). Before undertaking this activity, please submit a plan of your proposed action to the Regional Office for concurrence.

Thank you for your cooperation in this important dam safety matter. If you have any questions, please do not hesitate to call John Hawk at (312) 353-6168.

Sincerely,

Ronald A. Lesniak, P.E.  
Regional Director

**Tainter Gate Initiative, Revision 1 (2001)**

**FEDERAL ENERGY REGULATORY COMMISSION**

**901 MARKET STREET, SUITE 350  
SAN FRANCISCO, CA 94103**

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OFFICE OF THE SECRETARY

01 JAN 23 PM 2:39

FEDERAL ENERGY  
REGULATORY  
COMMISSION

January 18, 2001

In reply refer to:  
Project No. 2954-CA

Mr. David H. Johnson  
Director, Public Works Department  
City of Santa Barbara  
P.O. Box 1990  
Santa Barbara, CA 93102-1990

Dear Mr. Johnson:

Re: Tainter Gate Initiative Revision 1

Our letter to you, dated March 3, 1998, required inspection, analysis and testing be done on all of your tainter gates. As a result of our ongoing review of this tainter gate initiative, we have recognized the need to focus inspection, testing, and analysis efforts on gates whose failure would have dam safety or operational consequences. To this end, the FERC will now recognize 2 categories of tainter gates:

**Category 1- Failure or mis-operation (failure to operate) would have dam safety or operational consequences.**

1. Structural failure would endanger downstream life and property.
2. Failure to open or close would significantly effect the project's ability to safely pass a flood, endanger upstream life and property, or effect a project purpose or compliance requirement, including important environmental requirements.

**Category 2 - Failure would have minimal to no consequences.**

The requirements based on gate category are included in the Attachment. Gates will be considered Category 1 unless an justification for Category 2 is made by the licensee. The FERC will base its decisions on the following risk factors :

**Consequences of gate failure.** Gates can fail in both open and closed position. The upstream and downstream consequences of each failure scenario must be considered.

**Redundancy.** Gate failure at a site with many small gates may not be as serious as gate failure at a site with a few large gates.

**Operator Reliability.** If all gates are operated by one traveling hoist, then hoist failure becomes much more critical. (Common cause failure)

**Project function.** If failure of a gate makes it impossible for the project to function as intended, including fulfilling important environmental requirements, gate failure becomes more critical.

**Bulkhead Provisions.** If there is another method of stopping flow, the consequences of gate failure may be lessened.

If you have any questions concerning this matter please call Mr. Tilak Dhir at 415-369-3361. Thank you for your cooperation in this important dam safety initiative.

Sincerely,

**JAMES GORIS**  
James Goris, P.E.  
Regional Director

Attachment:

**FERC TAILTER GATE INITIATIVE  
 REVISION 1**

	Proposed →→	Category 1	Category 2
	Current FERC requirements ↓	1) Structural failure would endanger downstream life and property, 2) Failure to open or close would significantly effect the project's ability to safely pass a flood, endanger upstream life and property, or effect a project purpose or compliance requirement, including important environmental requirements.	Not Category 1.
Close-up Detailed Inspection	NA	10 yrs (every gate)	NA
Visual Inspection	1 yr	1 yr	2 yrs
Ampere Testing	1 yr	1 yr	NA
Full Height Testing	5 yrs	5 yrs	10 yrs
Operation Test	1 yr	1 yr	1 yr
Required Analysis	Static + Dynamic	Static + Dynamic	Static

The FERC will consider all Tailter Gates Category 1 gates unless the owner makes a case for Category 2.

**Tainter Gate Initiative, Revision 2 ( 2002)**

FEDERAL ENERGY REGULATORY COMMISSION  
Office of Energy Projects  
Division of Dam Safety and Inspections  
Portland Regional Office  
101 S.W. Main Street, Suite #905  
Portland, Oregon 97204

JUN 13 2008  
JUN 13 2007

P-2899, et al.

Re: FERC Tainter Gate Initiative, Revision 2

To Licensees on the Attached List:

By October 13, 2000 letter, we advised of a revision to our tainter gate initiative. As a result of feedback received from licensees and consultants, it is clear that the intended purpose of this revision, which was to focus inspection and analysis efforts on the gates of highest risk, was not achieved. This letter provides clarification and a few additional changes. We will recognize two categories of tainter gates:

**Category 1 - Structural failure or mis-operation (failure to operate) of gates would have dam safety or severe operational consequences.**

- 1) Structural failure of a gate or a gate's inability to open or close endangers downstream life and property during normal operations and flood events.
- 2) Failure to open or close results in a significant uncontrolled reservoir level rise or drop during normal operations or flood events affecting upstream property or resources.

**Category 2 - Structural failure or mis-operation would have minimal to no consequences.**

- 1) Gates located at low hazard potential dams.
- 2) A gate failing in the open or closed position would not impact the dam's ability to safely pass flood flows or affect upstream property or resources.

The requirements for each category are included in the attached table, FERC Tainter Gate Initiative, Revision 2. The requirements of Category 2 have been revised to be more in line with what is currently required at low hazard potential dams. The requirement for structural analysis has been removed, and the frequency of full-height

gate tests have been extended to once every 10 years. Annual gate testing requirements are as required by the regulations.

The general requirement for a dynamic analysis of Category 1 gates has also been deleted. Earthquake induced tainter gate failures are considered rare. Dynamic analyses will be required on a case-by-case basis for projects with large gates in severe seismic regions where the expected peak ground acceleration is high. Engineering judgment will be required when deciding to require a dynamic analysis. As a guideline, dynamic analysis will be required if peak ground acceleration is over .25g and the gate failure would result in loss of life. It should be understood that this does not relieve the project owner of the necessity of analyzing the gate piers or other gate related structural project features under the appropriate seismic loading.

Gates at high and significant hazard potential dams will be considered Category 1 unless an justification for Category 2 is made by the licensee. The decision will be based on the following risk factors :

**Consequences of gate failure.** Gates failure can have both upstream and downstream effects. A structural failure or a failure to close can result in the loss of the reservoir and endanger downstream life and property. A failure to open during a flood event can cause the reservoir to rise excessively, threatening the stability of the dam and causing flooding upstream. Of concern is a situation in which a small and frequent flood event is exasperated by a gate which cannot be opened. A gate failure could result in a loss of reservoir and the associated upstream recreational project purposes. The upstream and downstream consequences of each failure scenario must be considered under normal operations and flood flows.

**Redundancy.** Gate failure at a site with many small gates may not be as serious as gate failure at a site with few large gates.

**Operator Reliability.** If all gates are operated by one traveling hoist, then hoist failure becomes much more critical. (common cause failure)

**Project Function.** If failure of a gate makes it impossible for the project to function as intended, gate failure becomes more critical. Consider the impact on a significant reservoir related resource such as major recreation centers.

**Bulkhead Provisions.** If there is another method of stopping flow, the consequences of gate failure may be lessened. Can a breach flow be quickly

stopped with stoplogs or portable cofferdams? Can the gate bay be bulkheaded under flow conditions?

Please review the tainter gates associated with your project(s) and if deemed warranted, provide this office with copies of justification for those tainter gates you feel should be classified as Category 2.

Thank you for your cooperation in this important dam safety initiative. If you have any questions, please call Mr. Edward Perez of this office at (503) 944-6750.

Sincerely,

A handwritten signature in black ink, appearing to read "H. T. Hall". The signature is fluid and cursive, with a large initial "H" and a long, sweeping underline.

Harry T. Hall, P.E.  
Regional Engineer

Enclosure - FERC Tainter Gate Initiative, Revision 2

<b>FERC TAINTEGATE INITIATIVE REVISION 2</b>		
3/21/02		
	<b>Category 1</b>	<b>Category 2</b>
	1) A structural failure of a gate or a gate's inability to open or close endangers downstream life or property during normal operations and flood events.  2) A failure to open or close results in a significant un-controlled reservoir level rise or drop during normal operations or flood events affecting upstream property or resources.	1) Gates located at low hazard potential dams.  2) A gate failing in the open or closed position would not impact the dam's ability to safely pass flood flows or affect upstream property or resources.
Close-up Detailed Inspection	10 yrs	NA
Ampere Testing	1 yr	NA
Full Height Testing	5 yrs	10 yrs
Annual Operation Test	1 yr	1 yr
Required Analysis	Static <u>1/</u>	NA

1/ As a guide, dynamic analysis will be required if peak ground acceleration is over .25g and the gate failure would result in loss of life. It should be understood that this does not relieve the project owner of the necessity of analyzing the gate piers or other gate related structural project features under the appropriate seismic loading.

All tainter gates at high and significant hazard potential sites will be considered Category 1 gates unless the licensee provides justification for reclassification to Category 2.



**10-Year Gate Inspection Reminder (2009)**

April 28, 2009

**RE: Tainter Gate Initiative/Dam Owners Responsibilities**

Dear Licensee/Exemptee:

The FERC Tainter Gate Initiative was instituted in February of 1998 in response to the findings of the Bureau of Reclamations forensic investigation of the 1995 Folsom Dam gate failure. Since you are at or approaching the 10 year requirement for a detailed inspection of Category 1 gates, this letter is intended to remind you of the continuing responsibilities that you have under the FERC Tainter Gate Initiative. The table below provides a description of Category 1 and 2 gates and the inspection requirements under each Category of gate.

	<b>Category 1</b>	<b>Category 2</b>
	1) A structural failure of a gate or a gate's inability to open or close endangers downstream life during normal operations and flood events.  2) A failure to open or close results in a significant un-controlled reservoir level rise or drop during normal operations or flood events affecting upstream property or resources.	1) Gates located at low hazard potential dams.  2) A gate failing in the open or closed position would not impact the dam's ability to safely pass flood flows or affect upstream property or resources.
Close-up Detailed Inspection	10 yrs	NA
Ampere Testing	1 yr	NA
Full Height Testing	5 yrs	10 yrs
Annual Operation Test	1 yr	1 yr
Required Analysis	Static	NA

A report providing the results of the detailed inspection for your Category 1 gates should be provided with the submittal of your next gate certification due by December 31, 2009. Included with your report should be a plan and schedule to address any deficiencies noted during the inspection. If you are unable to perform the inspection and submit a report of the findings by December 31 you should submit a plan and schedule of when this can be accomplished for our approval.

All tainter gates at high and significant hazard potential dams are considered Category 1 gates by default. The following risk factors are considered to revise the categorization of a gate:

**Consequences of gate failure.** Gates can fail in both open and closed position. The upstream and downstream consequences of each failure scenario must be considered.

**Redundancy.** Gate failure at a site with many small gates may not be as serious as gate failure at a site with few large gates.

**Operator Reliability.** If all gates are operated by one traveling hoist, then hoist failure becomes much more critical. (Common cause failure)

**Project function.** If failure of a gate makes it impossible for the project to function as intended, gate failure becomes more critical.

**Bulkhead Provisions.** If there is another method of stopping flow, the consequences of gate failure may be lessened.

Explanation of Requirements:

1) **Close up Detailed Inspection.** The purpose of this inspection is to detect broken welds and bolts, fatigue cracks, and the initiation of corrosion. Observations from a distance are not sufficient for this purpose. If the inspector is not close enough to touch the gate feature he/she is inspecting, the inspection can not be considered a "Close up Detailed Inspection".

2) **Ampere Testing.** The purpose of this is to obtain a periodic easily obtainable spot check of operability of the gate machinery.

3) **Full Height Testing.** This must be performed periodically to insure that the gate can operate through its full intended travel in the event that extreme flood events occur.

4) **Annual Operation Test.** Every year the operational readiness of each gate must be demonstrated.

5) **Analysis**. Analysis previously performed in response to the Tainter Gate Initiative need not be re performed. However as with all analyses and studies contained in the STID, it is the responsibility of the Part 12 consultant to review and comment on the accuracy and appropriateness of tainter gate analyses. Gates may require re-analysis if changes have been made to the gates, or if anticipated loading conditions have changed. While static analyses will be sufficient for most gates, large high consequence gates in high seismic areas may require dynamic analysis.

If you have any questions, please call me at 503-552-2741.

Sincerely,

A handwritten signature in black ink, appearing to read "Pat Regan", written in a cursive style.

Patrick J. Regan, P.E.  
Regional Engineer

Enclosure: Annual Spillway Gate Operating Certificate

**Annual Spillway Gate Operation Certificate**

A link to download the most recent version of the annual spillway gate operation certificate can be obtained at the following address:

<http://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide.asp>