



California Public Utilities Commission

**INVESTIGATION REPORT
OF THE
AUGUST 3, 2013 IMPLOSION INJURY AT THE
KERN POWER PLANT OWNED BY
PACIFIC GAS AND ELECTRIC COMPANY**

PUBLIC REPORT

**PREPARED BY THE SAFETY AND ENFORCEMENT DIVISION
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**SAN FRANCISCO
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1. Summary

In the early morning of August 3, 2013, Pacific Gas and Electric Company (PG&E) imploded the boilers at its retired Kern Power Plant (Kern) with explosives. Located in Bakersfield, California, Kern provided power to the region until it closed in 1985. As the explosives went off and the boilers toppled, shrapnel ejected and sprayed a parking lot more than a quarter mile away. A crowd that had gathered to witness the event tried to take cover, but the shrapnel from the plant injured spectators and damaged cars and buildings.

SED's investigation determined that PG&E's subcontractor failed to properly design the implosion. As a result, the subcontractor overloaded the boilers with 15 times the proper amount of explosives, according to a root cause analysis. The excess explosives shattered steel columns and ejected metal shrapnel beyond the designated safety zone and into a crowd of spectators. SED's determination is consistent with the findings of a root cause analysis performed by Exponent at the direction of SED.¹

SED traced the root cause of this incident to PG&E's inadequate contractor safety management systems, including contractor qualification, selection, and oversight. These deficiencies undercut safeguards that could have prevented the accident. These same deficiencies were also identified as the underlying reasons for the June, 2012 fatal accident at the same site.

As part of a settlement in response to the 2012 fatal accident,² PG&E has developed a new Contractor Safety Program to significantly improve PG&E's contractor management systems and an Enterprise Causal Evaluation Standard to improve its evaluation of the cause of serious safety incidents. SED believes these corrective actions, if PG&E properly implements and maintains them, will adequately address the underlying root cause and ultimately resolve the safety implications of this implosion incident. Therefore, SED does not recommend that the Commission open a formal Order Instituting Investigation (OII) proceeding at this time. SED will, however, continue to monitor PG&E's implementation of its new Contractor Safety Program and Enterprise Causal Evaluation Standard. Further, SED will examine whether similar deficiencies exist at other utility companies, and whether the Commission should consider requiring similar safety programs at those companies.

¹ Exponent is a global engineering and scientific consulting firm that specializes in forensic and failure analysis.

² The Commission approved this settlement in Decision (D.) 15-07-014.

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2. Incident Description

On August 3, 2013 at approximately 6:00 a.m., Pacific Gas and Electric Company (PG&E) detonated explosives to topple the boilers at its retired Kern Power Plant in Bakersfield, California. The implosion did not go as planned. Shrapnel from the collapsing structure flew over a thousand feet and sprayed a Lowe's parking lot where a group of people had gathered to witness this historic event. Steel fragments hit and injured at least five spectators, one critically, and damaged nearby cars and buildings.

PG&E built the Kern plant between 1945 and 1950, and operated it from 1948 until 1985. The plant provided 180 megawatts of power to the region with a boiler and a steam turbine generator. In 1985, the plant was placed in cold stand-by, and in 1994 the generation production assets were retired from PG&E's books.³ In 2011, PG&E began to demolish the plant. The boiler implosion was part of PG&E's demolition plan.

In March 2012, PG&E hired URS's Cleveland Wrecking Company (Cleveland) as the prime contractor to lead the demolition effort. Cleveland removed asbestos and lead and demolished equipment, such as fuel oil tanks and building foundations, with mechanical means. The boilers were the last structures to be demolished.

Due to its lack of explosives expertise, Cleveland subcontracted with Demtech LLC (Demtech), an out-of-state company, to design and carry out the implosion. But in the days leading up to the planned implosion, Demtech was unable to secure the necessary permits and licenses.^{4 5 6} As a result, Cleveland subcontracted with Alpha Explosives, Inc. (Alpha), a California firm, to provide the needed documents. Demtech, however, remained the sole architect of the implosion.

³ See, D.04-05-019 at 2-3 and D.01-04-004.

⁴ Cal/OSHA requires a permit for the demolition of any structure over 36 feet. It also requires anyone who uses explosives for demolition to obtain a blaster's license.

⁵ Contractors State License Board requires demolition contractor to obtain a C-21 license.

⁶ Kern County requires an Explosive Use Permit to use, store or transport explosives.

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Photo 1: Kern Power Plant Boilers Implosion. *Source:* <https://www.youtube.com/watch?v=6N3p-CbSkU8>

3. SED Investigation

SED investigated the implosion incident. Based on the facts and evidence gathered and examined, SED found that PG&E's subcontractor Demtech failed to properly design the implosion. As a result, the subcontractor overloaded the boiler support columns with explosives. The excess explosives disintegrated the steel columns, and the resultant force ejected metal shrapnel beyond Demtech's (inadequate) safety zone and into a crowd of spectators.

On August 3 and 4, 2013, SED inspected the site to gather visual evidence and to talk with PG&E personnel. Due to a worker's fatality the prior year, also involving Cleveland at Kern, SED took extra precaution and directed PG&E to clear the site of possible remnant explosives.⁷ SED also directed PG&E to preserve all evidence and to conduct a full Root Cause Analysis (RCA) before PG&E resumed any demolition work.⁸

On September 18, 2013, SED requested pertinent data regarding the implosion, including Demtech's Explosive Demolition Plan (or blast plan) that described which support columns were to be blasted, the type and amount of charges to be used, and how the boilers were designed to collapse. SED also

⁷ SED had required and PG&E created a contingency plan for remnant explosives. Demtech subsequently performed a post-blast analysis and determined that all explosives were detonated. No remnant explosives were ultimately found.

⁸ SED's Letter and Data Request dated August 20, 2013

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requested key information such as calculation or basis for determining the blast loads (e.g. test blasts), and the type of blast shields used to contain fragmentation.⁹

In its investigation, SED found that Demtech failed to properly design the implosion. SED found no evidence that Demtech:

1. Used any scientific approach to determine the proper blast loads,
2. Applied scientific criteria to calculate the proper safety zone distance,
3. Prescribed adequate blast shields to contain flying debris or fragmentation,
4. Consulted an engineer or reviewed structural drawings to analyze the boiler structure, or
5. Used computer modeling to simulate and validate its implosion design.

First, Demtech failed to use any scientific approach to determine the proper blast loads, including which type or how much explosives to use for the implosion. Demtech's blast plan prescribed the use of UNIGEL[®] in Linear Shaped Charges (LSC) to explosively-cut the columns.¹⁰ It stated that it will match the LSC's size to the respective steel column to be cut. In using LSC, there must be a precise standoff from the surface to be cut.¹¹ This standoff is computed based on the explosive's density (grains per foot) in the shaped charges and the metallurgy of the steel to be cut. In its blast plan, Demtech stated that it will calculate and employ the proper standoff to maximize severing effect and minimize explosives used. This optimum standoff will also minimize air blast and shrapnel broadcast. However, SED found no evidence that Demtech calculated the standoff nor conducted a test blast to determine the proper blast loads.

⁹ SED's Letter and Data Request dated September 18, 2013

¹⁰ UNIGEL[®] is the trade name for a semi-gelatin dynamite made by explosives manufacturer Dyno Nobel. A linear shaped charge is an explosive charge shaped linearly so as to focus the explosive's energy to produce a linear cut. The focus of the explosive's high pressure wave, as it detonates, results in a cutting force. The wave impacts the metal with pressures greater than its yield strength, literally pushing the steel material to either side of the jet's path.

¹¹ Standoff is the distance between the steel surface to be explosively-cut and the mounting explosive. If the charge is too close to the surface, there'll not be enough time for the explosive jet to develop fully as it detonates. If it's too far, the jet disperses. Either case lessens the explosive's cutting force.

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Photo 2: UNIGEL[®] Linear Shaped Charges. *Source: PG&E*

The plan also prescribed the use of a UNIGEL[®] kicker charge. The kicker charge is designed to detonate after the column is explosively-cut by LSC. Its purpose is to kick the severed support column out so that the structure the column supports can collapse. Again, SED found no evidence that Demtech performed any calculation or a test blast to determine the right amount of explosives to use in the kicker charge.



Photo 3: UNIGEL[®] Kicker Charges. *Source: PG&E*

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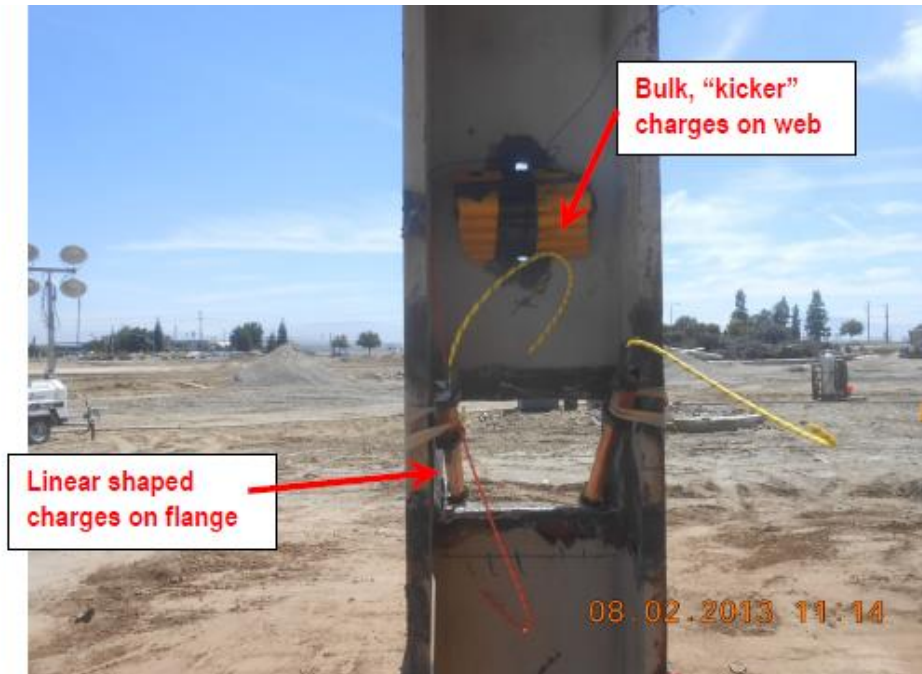


Photo 4: Explosives Installation. Kicker charge is designed to go off after the LSC explosively-cut the column. Its purpose is to kick the severed support column out so that the structure the column supports can collapse. *Source: PG&E*

In response to SED’s inquiry about a test blast, Demtech stated that it did not conduct such a test because “*the support columns were of a similar makeup as other power plant structures that have been shot on recent projects.*” Demtech failed to recognize that metals used during Kern’s construction could have deviated from specifications.¹² A test blast or a metallurgical analysis would have been a more scientific approach.

Second, Demtech failed to apply scientific criteria to calculate the proper safety zone distance. Demtech’s specified safety zone of an 800-foot radius was too small, as shrapnel flew over 1,400 feet from the blast zone into the Lowe’s parking lot.¹³ This safety zone also contradicted with Demtech’s own plan which “*strongly suggested that ALL personnel within ½ mile [2,640 feet] of the event be behind cover.*”¹⁴ In response to SED’s question on how it determined the safety zone distance, Demtech stated that the safety zone was determined based on “*Distances of recognized industry standards and past experience (reviewing of numerous surface building structure blasts and bridge demolition project video tapes looking for shrapnel impacts on water or grounds in the blast area).*” This approach is subjective at best and archaic at worst, as it failed to consider the site’s unique topography and the physical properties of the columns. No two implosions are alike. Demtech failed to properly determine the proper safety zone distance.

¹² Subsequent metallurgical analysis revealed that column steel is ASTM (American Society for Testing and Materials) A-7 steel and met proper specifications at the time of construction. *Source: Exponent’s Kern Power Plant Boiler Demolition Root Cause Analysis dated April 13, 2015 (Page 36)*

¹³ A steel fragment weighing approx. 3 ½ pounds was recovered from the Lowe’s Garden Center and logged as Exhibit U.

¹⁴ Demtech’s Explosive Demolition Plan for PG&E Kern Power Plant (Page 7)

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Photo 5: Shrapnel flew as far as 1,400 feet from the blast zone.

Third, Demtech failed to prescribe adequate blast shields to contain flying debris or fragmentation. In response to SED's inquiry about blast shields, Demtech stated *"We prefer to use custom built wood boxes lined with conveyer belting and wrapped with heavy woven Geo-Tech fabric. We have blasted many steel structures with greater quantities of explosives and at closer distances than this project, and with no resulting damage."* This re-illustrated Demtech's faulty approach and its reliance on judgement based on past projects. Further, SED found no evidence that conveyer liner or geo-fabric were used to reinforce the wood shields. Demtech also underestimated the potential for damage or injury from flying debris, as evidenced by this statement in its blast plan: *"On this project the exposure to other structures is worthy of consideration but not of alarming concern."*¹⁵

¹⁵ Demtech's Explosive Demolition Plan for PG&E Kern Power Plant (Page 9)

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Photo 6: Plywood boxes installed over LSC and kicker charge to contain flying debris.

And finally, Demtech failed to consult an engineer or use computer modeling to simulate the implosion. A structural or metallurgical engineer could have offered crucial insights regarding the structural integrity or mechanical properties of the support columns, which Demtech could have used to change or at least scrutinize its implosion design. However, Demtech failed to confer with subject matter experts, and further failed to use computer modeling tools that are widely available to simulate and validate its implosion design.

Based on its examination, SED found that Demtech failed to properly design the implosion and that its blast plan was “generic” at best. This finding is consistent with an industry expert’s opinion.¹⁶ Demtech failed to exercise due diligence and misjudged severely. SED found repeated evidence that Demtech based its design on faulty assumptions derived from limited or inapplicable past experience rather than scientific data or site-specific analysis. In fact, Demtech had only limited experience with power plant implosion.¹⁷ Consequently, Demtech overloaded the boilers with explosives. This resulted in the shattering of steel columns and the dislodging of shrapnel beyond an improperly determined and inadequate safety zone, and ultimately led to bodily injury and property damage.¹⁸

¹⁶ A professional opinion issued by Controlled Demolition Incorporation dated January 22, 2015 stated “My review of the Explosive Demolition Plan presented by Demtech/Alpha is that its format and language appears to be more of a proposal format, rather than a project-specific plan or procedure. The language of the document suggests that a proposal template created to match many types of explosives demolition projects was modified to refer to the KPP [Kern] project. As a result, in my opinion, the Demtech/Alpha Explosive Demolition Plan was never fully taken to a site-specific Explosive Demolition Plan that adequately detailed the procedures to be used for the safe explosive demolition of the KPP boilers.”

¹⁷ Demtech had performed only four power plant implosions in Ohio and Texas, all prior to 2011.

¹⁸ In January 2014, Cal/OSHA cited Demtech (Citation #316980630) and Alpha (Citation #316980598) for violations of California Code of Regulations Title 8. Both companies are appealing the citations. Cal/OSHA found no wrongdoing on the part of Cleveland and did not cite Cleveland.

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SED's finding concurred with the result of a consultant's root cause study. In response to SED's direction, PG&E hired Exponent to conduct a full RCA. Exponent concluded that the "*direct cause of the incident was use of an excessive quantity of explosives*".¹⁹ It estimated that Demtech overused explosives by a factor of 15. This conclusion was based on examination of metal fragments, metallurgical analysis of steel columns, mathematical calculations, and computer modeling.

4. Root Cause

SED attributed the underlying root cause of this incident to PG&E's inadequate contractor qualification, selection, and oversight processes. These deficiencies led to PG&E's incorrect assessment and selection of Cleveland. They also resulted in improper management and oversight of Cleveland. These same defects, which are inconsistent with PG&E's obligations under California Public Utilities Code section 451, were also identified as the underlying reasons for the June 2012 fatal accident at the same site.

SED previously conducted a separate investigation on the 2012 fatal accident at Kern.^{20 21} While dismantling an oil tank, a Cleveland worker fell and suffered fatal injuries. In that investigation, SED found that PG&E failed to adequately validate Cleveland's self-reported safety data. As a result, PG&E erroneously assessed Cleveland and ranked it higher in safety than it should have been. This led to the faulty selection of Cleveland in the competitively bid process.

Further, PG&E's bid criteria weighed heavily on price. PG&E based [REDACTED] of the total contractor score on price. SED found that Cleveland's bid was [REDACTED] lower in price than the next closest bidder, which also favored Cleveland in the bid process.

In regards to oversight, SED found that PG&E sought to transfer its oversight responsibilities to Cleveland. In its contract with Cleveland, PG&E stated "*Cleveland has full responsibility for the safety and safety oversight of any and all activities that take place on the site.*" PG&E also stated repeatedly that Kern was a "turn-key" project whereby Cleveland was given care, custody, and control of the site and that Cleveland had full responsibility for the safety of the people onsite.

SED found these same deficiencies reemerged as key contributing factors in the August 2013 incident, as shown by the following:

- Cleveland colluded with Demtech and Alpha in unprofessional conduct. Because Demtech, as an out-of-state company, lacked the necessary permits and licenses and was unable to secure them in time to implode the boilers, Cleveland subcontracted with Alpha only days before the implosion. While Alpha (an in-state company with proper permits and licenses) then fronted the

¹⁹ Exponent's Kern Power Plant Boiler Demolition Root Cause Analysis dated April 13, 2015 (Page 3)

²⁰ SED's Investigation Report of the June 19, 2012 Fatality at the Kern Power Plant owned by PG&E dated August 2014

²¹ The Commission opened Investigation (I.) 14-08-022 (filed August 28, 2014) to investigate the June 2012 fatal accident. Subsequently, PG&E settled with SED and Bayview/Hunters Point Community Legal on penalties and a commitment to develop and implement a Contractor Safety Program and an Enterprise Causal Evaluation Standard. In February 2015, parties filed a motion to seek the Commission's approval on the settlement. On July 23, 2015, the Commission approved the settlement in D.15-07-014.

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demolition for Cleveland, in reality Demtech remained the sole architect of the implosion. This unethical conduct bypassed the very regulatory safeguards that might have prevented the accident.

- Cleveland's criteria used to hire Demtech (and subsequently Alpha) were highly questionable with regards to safety and qualifications. Neither Demtech nor Alpha had substantial experience with explosive power plant demolition. Demtech had performed only four power plant implosions in Ohio and Texas, all prior to 2011. And Alpha had NEVER performed any power plant implosions.
- Cleveland failed to solicit independent review and verification of Demtech's design. Demtech's blast plan was fundamentally flawed because it relied purely on its limited experience rather than on a scientific approach.

These facts suggest that Cleveland's culture did not put safety as its utmost priority. Had PG&E's procurement processes been more robust, Cleveland would not have been selected, and perhaps both incidents could have been averted.

In August 2013, PG&E ultimately dismissed Cleveland due to its failure to perform. PG&E subsequently hired a new contractor, Silverado, based on more stringent requirements.²² Silverado resumed demolition in July 2014 and demolished the remaining boilers without further incident.²³

5. PG&E's New Contractor Safety Program and Enterprise Causal Evaluation Standard

In response to SED's investigation and the Commission's proceeding into the June 2012 fatal accident at Kern, PG&E developed a new Contractor Safety Program and an Enterprise Causal Evaluation Standard.²⁴ SED believes PG&E's new programs, if effectively implemented and maintained, will adequately address the underlying root cause and safety implications of this incident. Therefore, SED does not recommend that the Commission open another formal proceeding.

PG&E's new Contractor Safety Program is designed to improve its processes in the areas of contractor qualification, selection, and oversight, of which SED found deficiencies that attributed to the implosion injury. The program establishes minimum requirements for qualifying contractors and subcontractors that perform work for PG&E. PG&E has committed to qualify contractors and subcontractors per these new requirements by December 2015 and 2016, respectively.

The new Contractor Safety Program also provides PG&E employees who manage contractors more guidance on oversight roles and responsibilities. PG&E has committed to develop safety oversight procedures for each of its Lines of Business (defined as Electric Operations, Gas Operations, Nuclear, Information Technology, Customer Care and Safety and Shared Services) by December 2015. PG&E will implement these procedures by December 2016.

²² SED reviewed the criteria upon which Silverado was qualified and selected as a replacement contractor.

²³ PG&E resumed demolition before completing an RCA because evidence needed to conduct an RCA was buried under the collapsed boilers. In April 2015, PG&E completed its RCA.

²⁴ Commission D.15-07-014, issued on July 30, 2015, describes PG&E's new Contractor Safety Program and Enterprise Causal Evaluation Standard in more detail.

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PG&E will also add new safety provisions to enhance its contract terms with contractors. For example, the new terms more clearly define a contractor's obligations with regards to workers' training, safety inspection, and insurance. The new terms also allow PG&E to prescribe more stringent safety precautions, stop work in unsafe situations, and terminate the contract if a contractor fails to comply with PG&E's contractor safety program requirements. PG&E will add new terms in new contracts and amend existing contracts by December 2016.

PG&E's new Enterprise Causal Evaluation Standard provides enterprise-wide guidance for evaluating the cause of serious safety incidents and applies the evaluation standard to near-hit events. PG&E has committed to implement the procedures for each of its Lines of Business by the end of 2015.

6. SED's Conclusion and Recommendation

SED believes that PG&E's new Contractor Safety Program and Enterprise Causal Evaluation Standard, if properly implemented and maintained, will resolve the safety concerns derived from the August 2013 implosion accident. Therefore, SED does not recommend the Commission open another formal proceeding. However, SED will continue to monitor PG&E's corrective actions to:

- Qualify contractors and subcontractors by December 2015 and 2016, respectively,
- Develop and approve oversight procedures for each of its Lines of Business by December 2015,
- Implement oversight procedures by December 2016,
- Enhance contract terms in all **new** contracts and amend **existing** contracts by December 2016, and
- Implement the Enterprise Causal Evaluation Standard by the end of 2015.

Further, SED will examine contractor management systems and causal evaluation practices at other utilities for similar deficiencies.