



CSB Public Meeting

February 7, 2010, Natural Gas Explosion

Kleen Energy

Middletown, Connecticut

June 28, 2010



Tonight's Speakers

Lauren Wilson
Chemical Incident Investigator

Dan Tillema
Chemical Incident Investigator

Don Holmstrom
Investigations Supervisor





Tonight's Proceedings

- **Description of Kleen Energy Plant**
- **Incident Background**
- **Investigation Findings and Conclusions**
- **Similar Incidents**
- **Alternative Pipe Cleaning Methods**
- **Codes, Standards, and Regulations**
- **Delivery of Proposed Urgent Recommendations**

An aerial photograph of a large industrial facility, likely a chemical plant or refinery. The image shows a complex of buildings, pipes, and large cylindrical storage tanks. The scene is dominated by a large, long building with a flat roof and several smaller structures. In the foreground, there are several large, white, cylindrical tanks with circular openings on top. The overall scene is industrial and detailed.

Discussion of Kleen Energy Incident



Electricity Generated in Combined-Cycle Plant



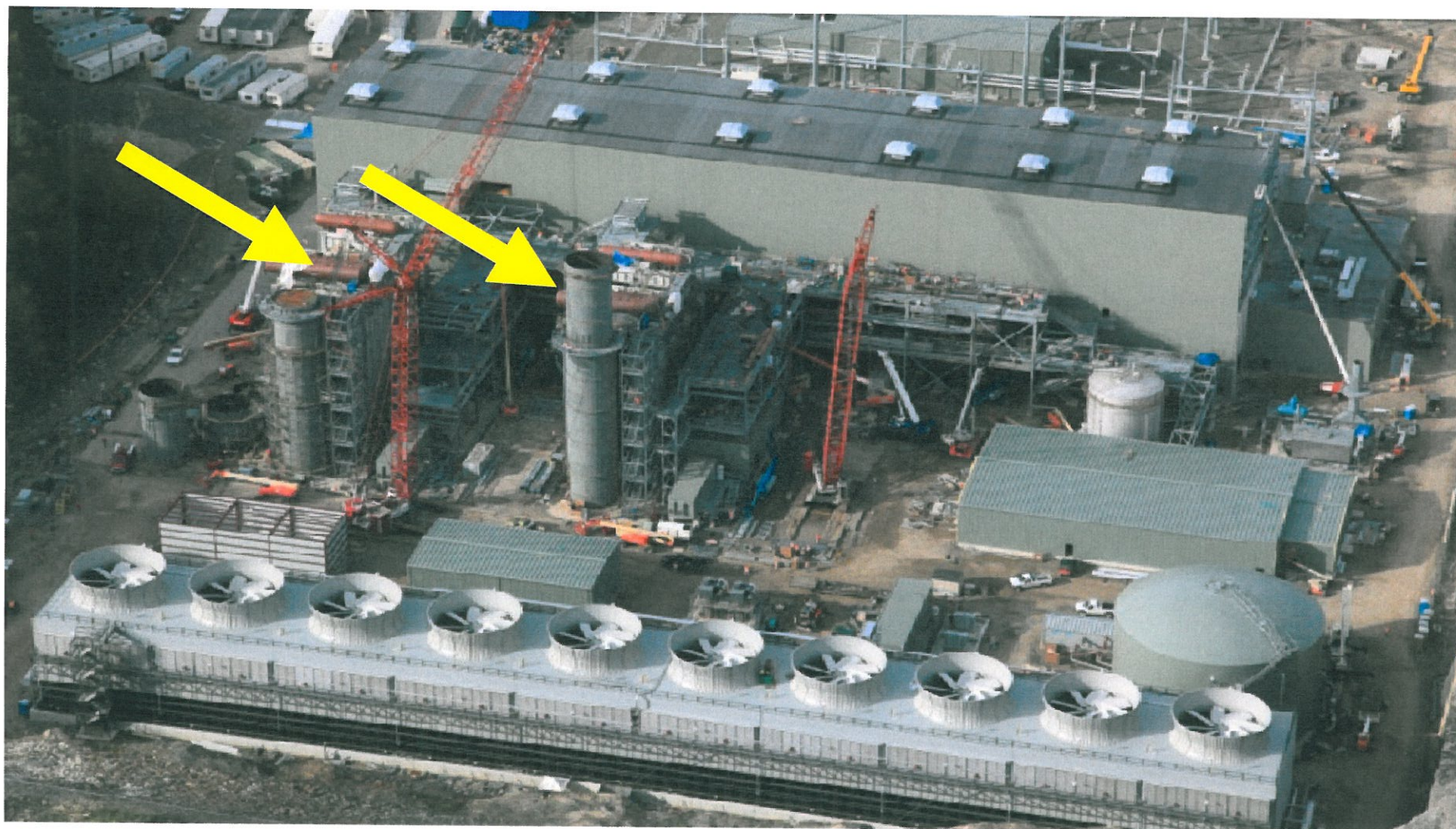


Electricity Generated in Combined-Cycle Plant



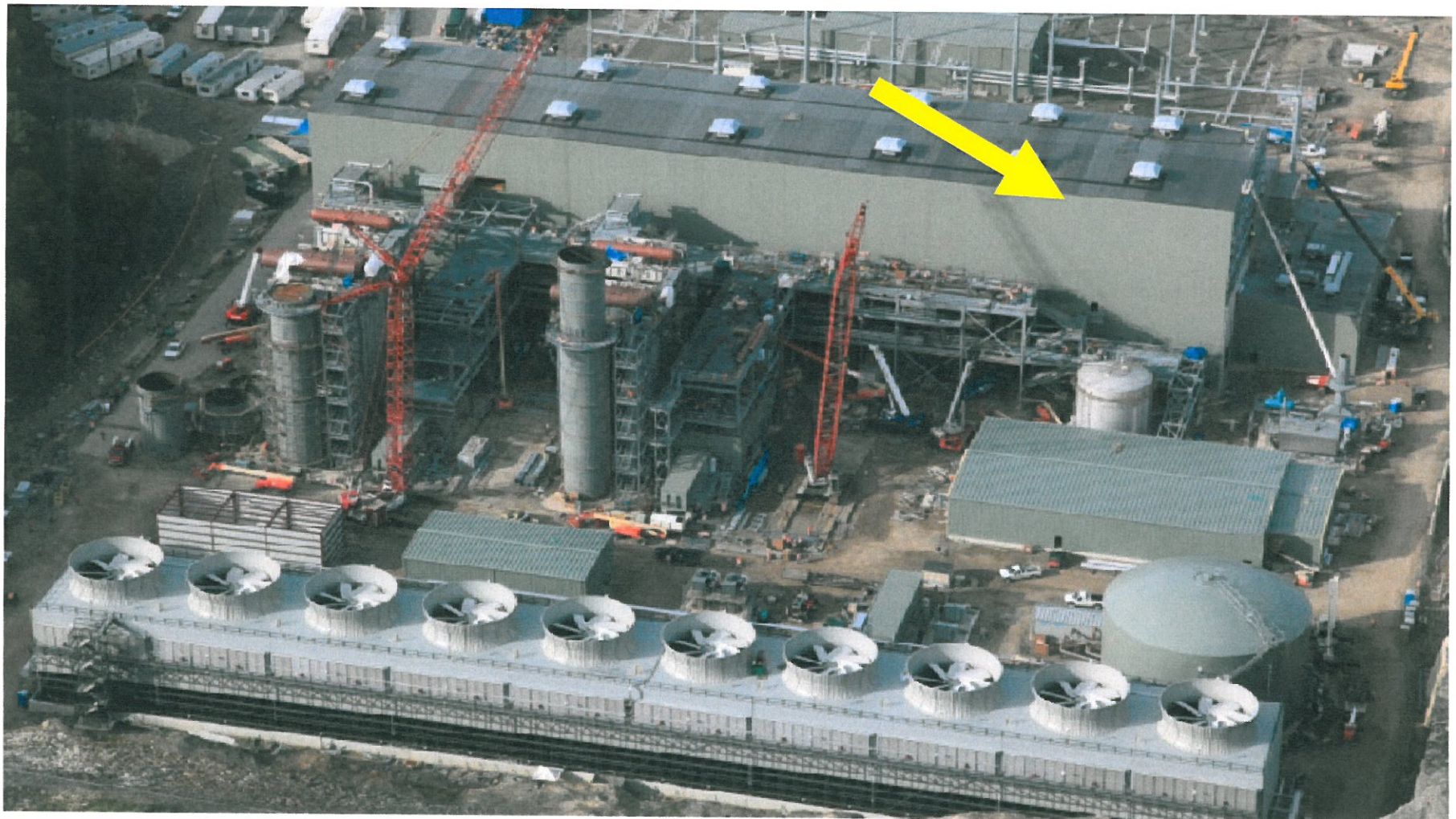


Electricity Generated in Combined-Cycle Plant



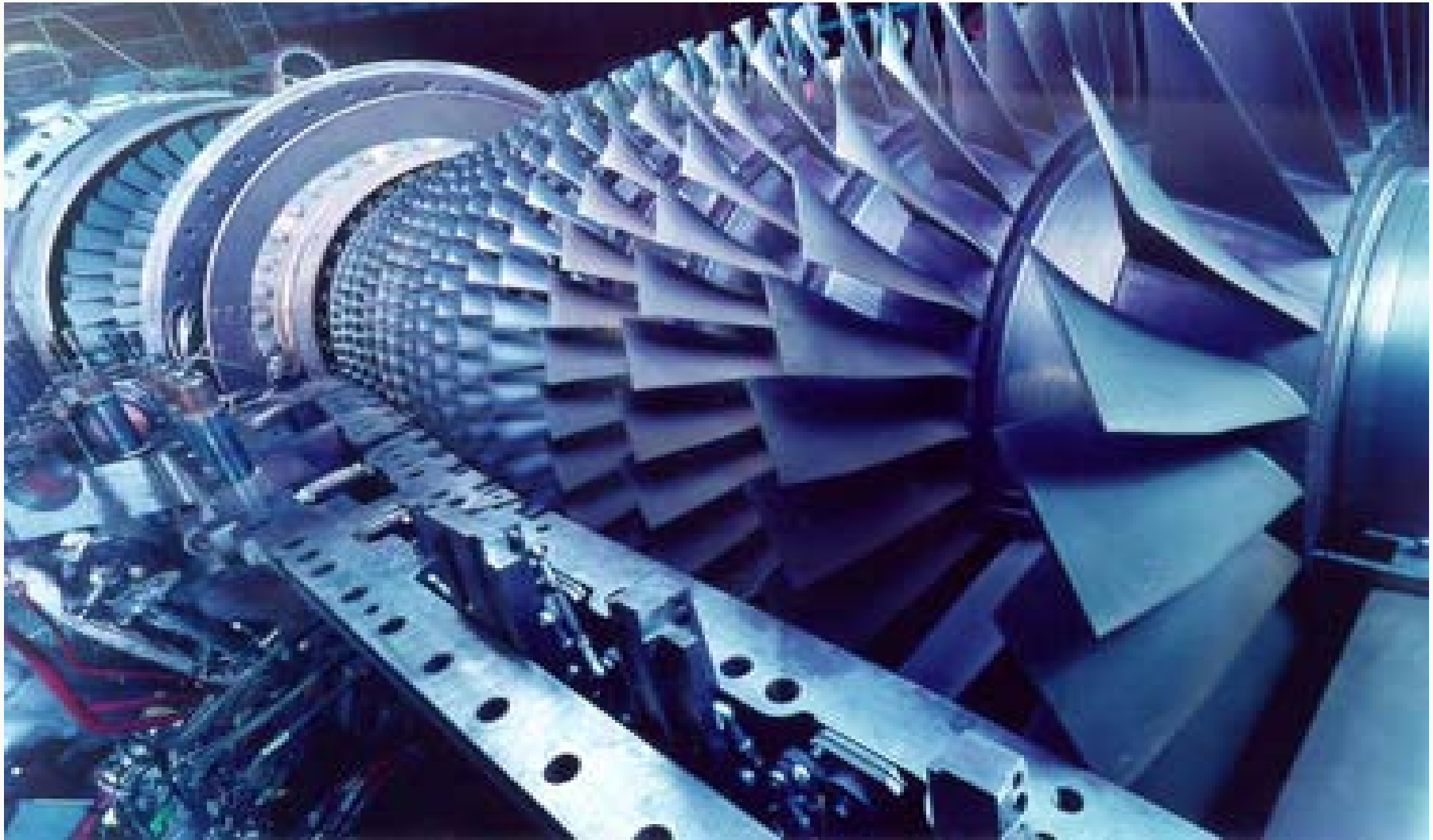


Electricity Generated in Combined-Cycle Plant





Debris in Gas Can Damage Turbine Blades





Gas Blow Led to Explosion

- Piping cleaned by “gas blow”
- Flow a large volume of high pressure natural gas through pipes to atmosphere to remove debris
- Large quantity of flammable natural gas was released
- This led to the explosion





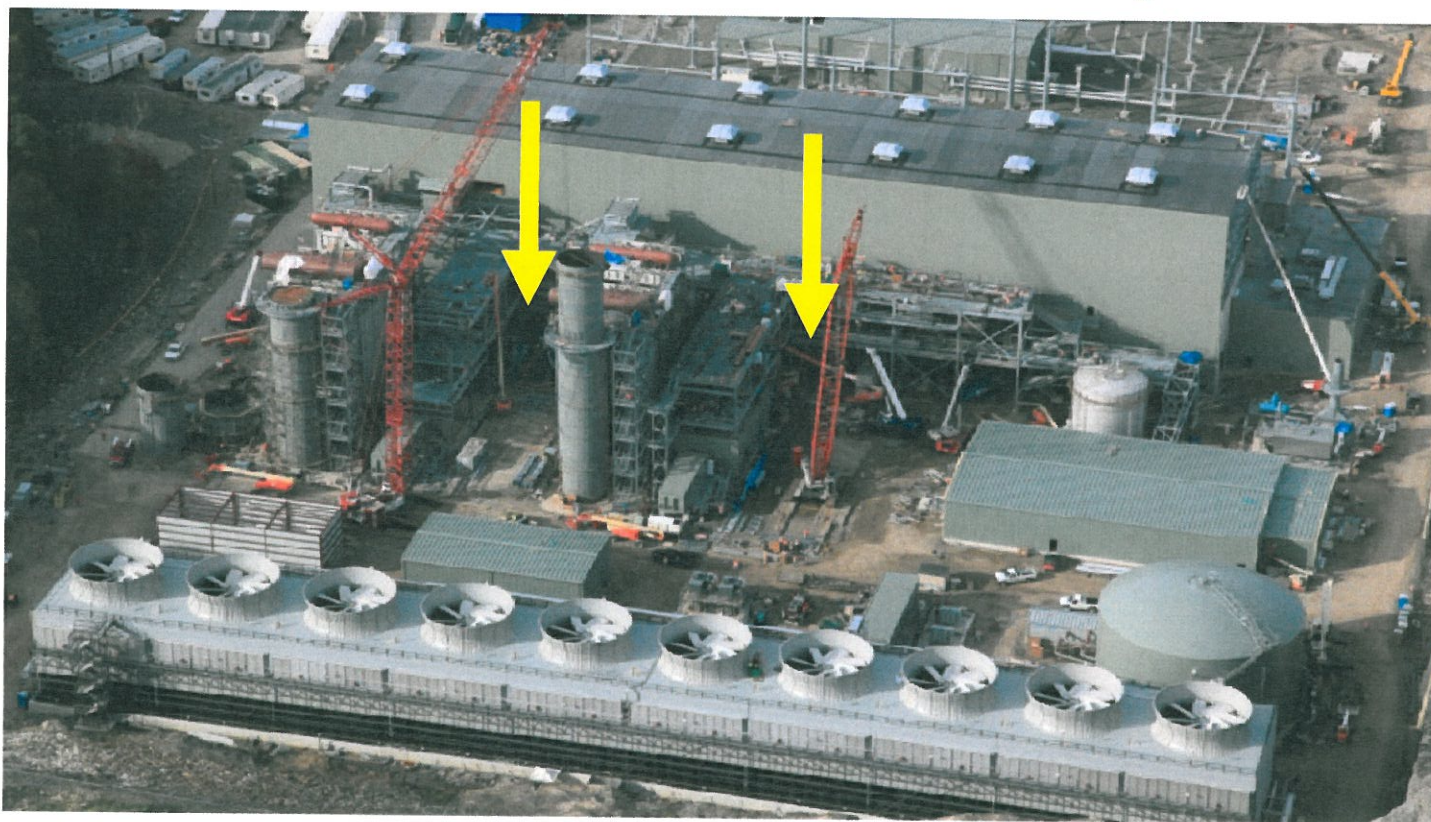
15 Natural Gas Blows Performed Day of Incident



Gas blows were performed intermittently over the morning of the accident



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Restricted Area Limited During Gas Blows



Many people were in the vicinity performing construction activities during the gas blows



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Flammable Gas Cloud Caused Explosion



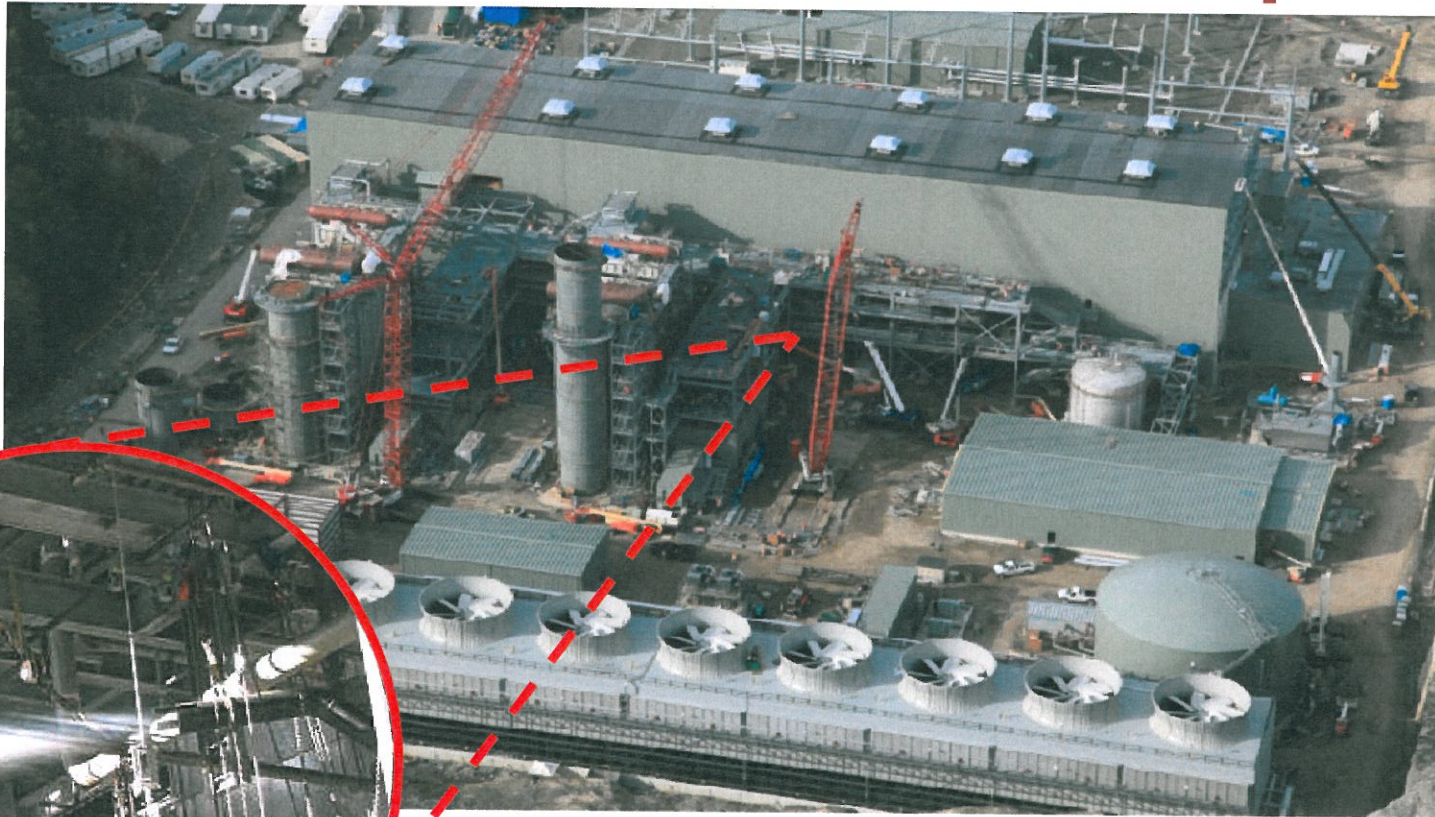


Flammable Gas Cloud Caused Explosion



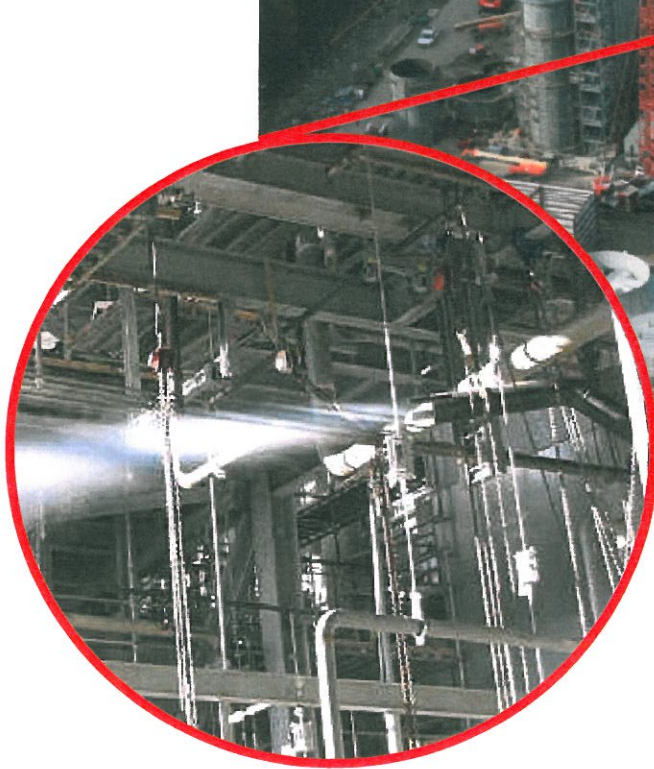
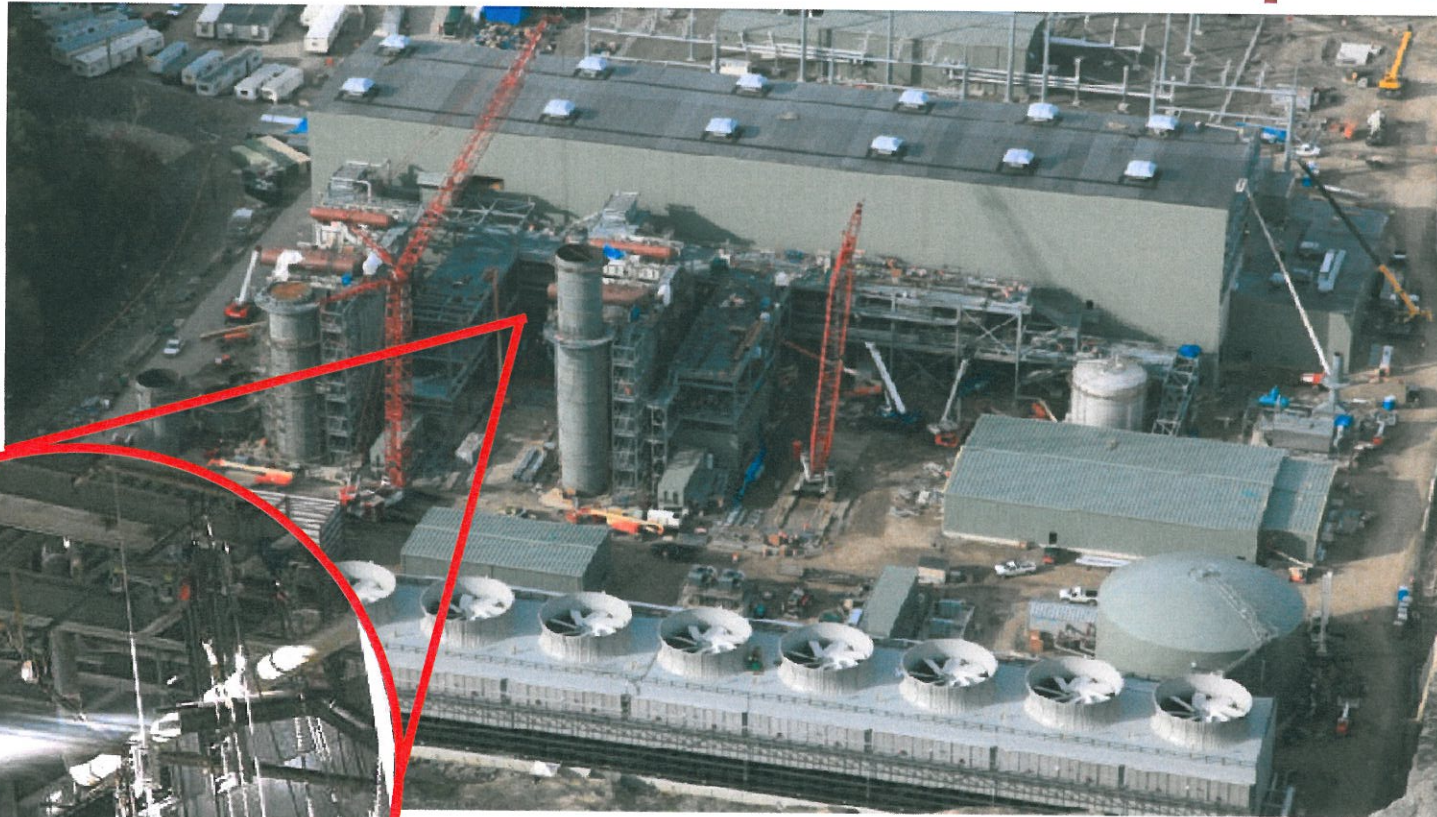


Flammable Gas Cloud Caused Explosion





Flammable Gas Cloud Caused Explosion





Flammable Gas Cloud Caused Explosion





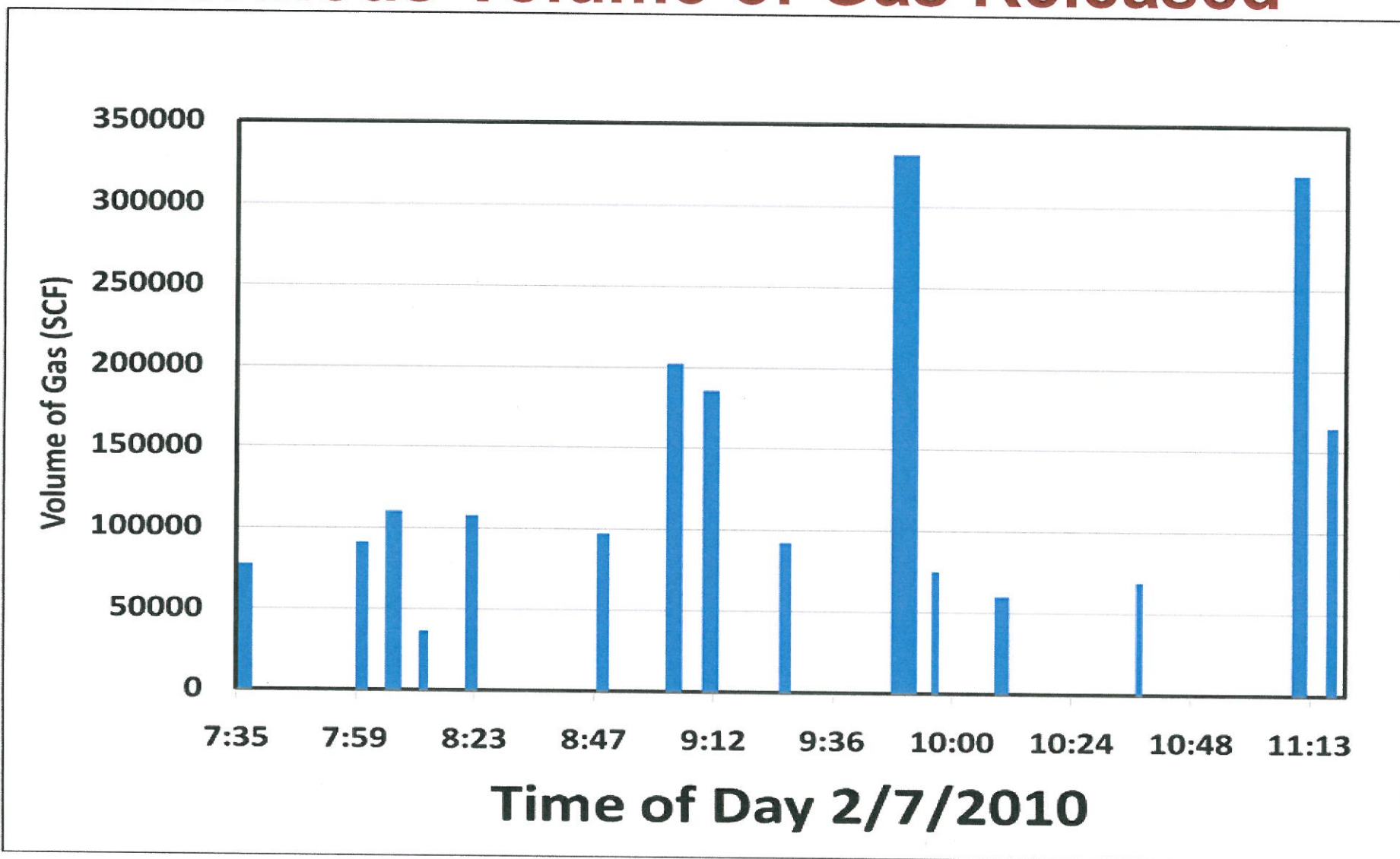
Consequences

- **6 Deaths**
- **Many injuries**
- **Significant damage to ~ \$1 billion facility**





Enormous Volume of Gas Released





Enormous Volume of Gas Released

**Enough gas released to
fuel a typical American
home every day for more
than 25 years**



Multiple Ignition Sources Present

- **Avoiding release of flammable gas is best way to avoid explosion**
- **CSB did not determine the ignition source**
- **Gas blow itself can be self-igniting**
 - Static electricity
 - Expelled metal debris sparking against nearby structures
- **Ignition sources present inside building (electrical power to building, people welding, heaters running)**



Previous Gas Blow Incidents



Similar Fire Occurred at FirstEnergy

October 2001 in Lorain, Ohio

- **Gas blow method used to clean fuel gas piping**
- **Gas unexpectedly ignited, causing a flame to shoot 30 to 40 feet into the air**
- **Gas blow was self igniting**
 - Metal debris struck nearby structure



Similar Explosion Occurred at Calpine

January 26, 2003 – Explosion occurred as a result of a gas blow at Calpine's Wolfskill power plant in Fairfield, California





Turbine Manufacturers Require Gas Cleanliness

- Target used to indicate cleanliness
- Turbine manufacturer representative often present during cleaning activities to verify pipe cleanliness





Gas Turbine Manufacturer	Percentage of Plants Purchasing Turbines Between 2010 - 2015
GE	63%
Siemens	19%
Solar	11%
Mitsubishi	4%
Pratt & Whitney	1.5%
Rolls-Royce	1.5%

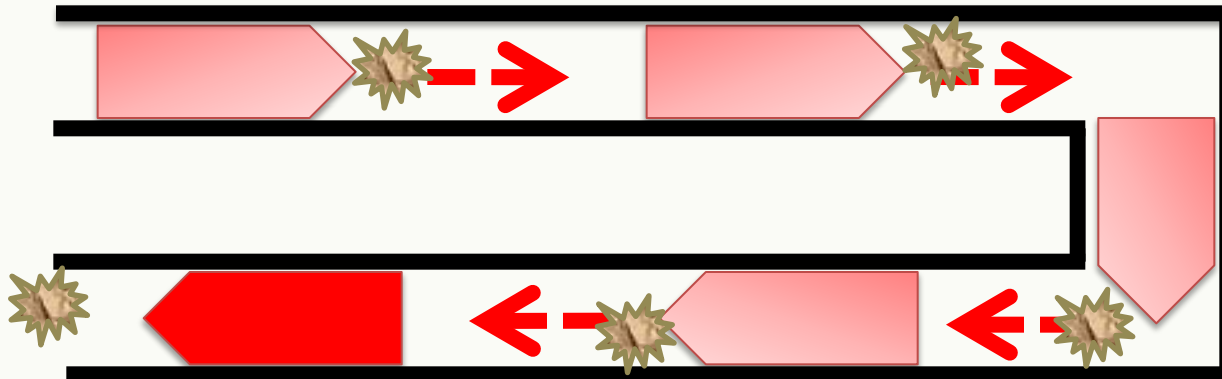
Platts World Electric Power Plants Database, 2010



Other Gas Pipe Cleaning Methods

- Air and nitrogen blows
 - Perform exactly the same function as gas blows
 - Nitrogen is an asphyxiation hazard

- Pigging



- Steam blows, water or chemical cleaning

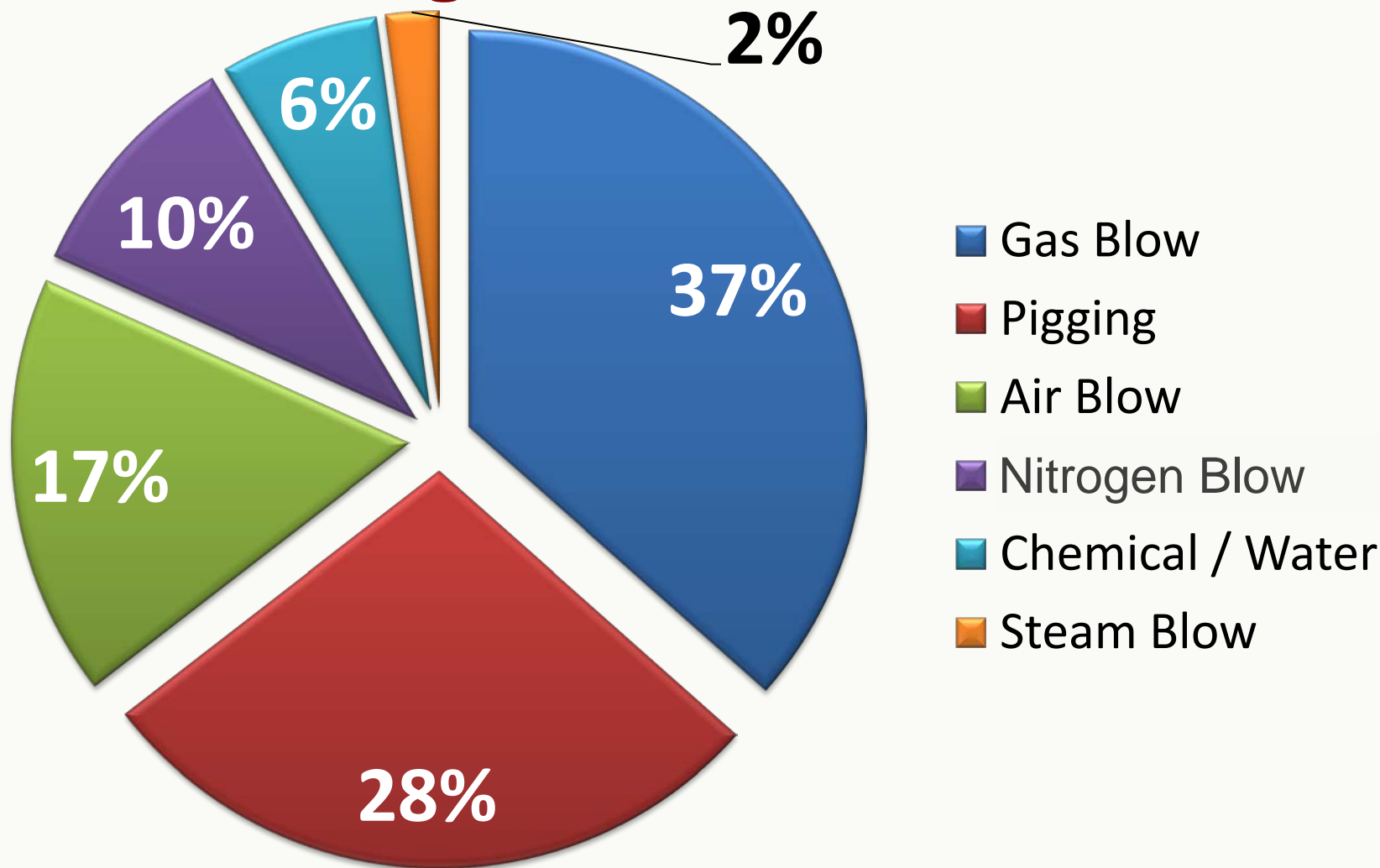


Combined Cycle Survey Results

- **CSB conducted a survey with the assistance of the Combined Cycle Users Group**
- **CSB received 62 responses from Combined Cycle Users Group members**
- **63% indicated use of “Gas Blows”**
 - Only 1 indicated use of flare to safely destroy flammables



Safer Cleaning Alternatives are Common





Technical Evaluation Minimizes Gas Release

- **Lack of technical evaluation can result in release of far more gas than is necessary**
- **“Cleaning Force Ratio” used to determine minimum gas flow needed to clean piping**
- **Minimum CFR at Kleen Energy exceeded**
- **Significantly more gas was released than was actually needed to clean the piping**



Gas Blows Require Evaluation of Many Factors

- **Need technical evaluation of factors including:**
 - Height, location, and orientation of vent pipe
 - Velocity and density of discharging gas
 - Potential ignition sources
 - Personnel location
 - Wind speed
 - Dispersion analysis
- **These considerations are not necessary in other cleaning methods, such as air blows**

An aerial photograph of a large industrial facility, likely a chemical plant or refinery. The image shows several large, cylindrical storage tanks in the foreground, a complex network of pipes and scaffolding, and several large industrial buildings with flat roofs. The overall scene is a detailed view of a major industrial site.

Review of Current Codes and Standards



NFPA Codes Provide No Guidance on Fuel Gas Pipe Cleaning

- **NFPA 54**
 - Does not address safe practices for cleaning fuel gas piping
 - Explicitly exempts fuel gas piping in power plants
- **NFPA 37**
 - Provides no guidance on how to clean gas piping without creating fire and explosion hazard
- **NFPA 850**
 - Does not address safe practices for cleaning fuel gas piping



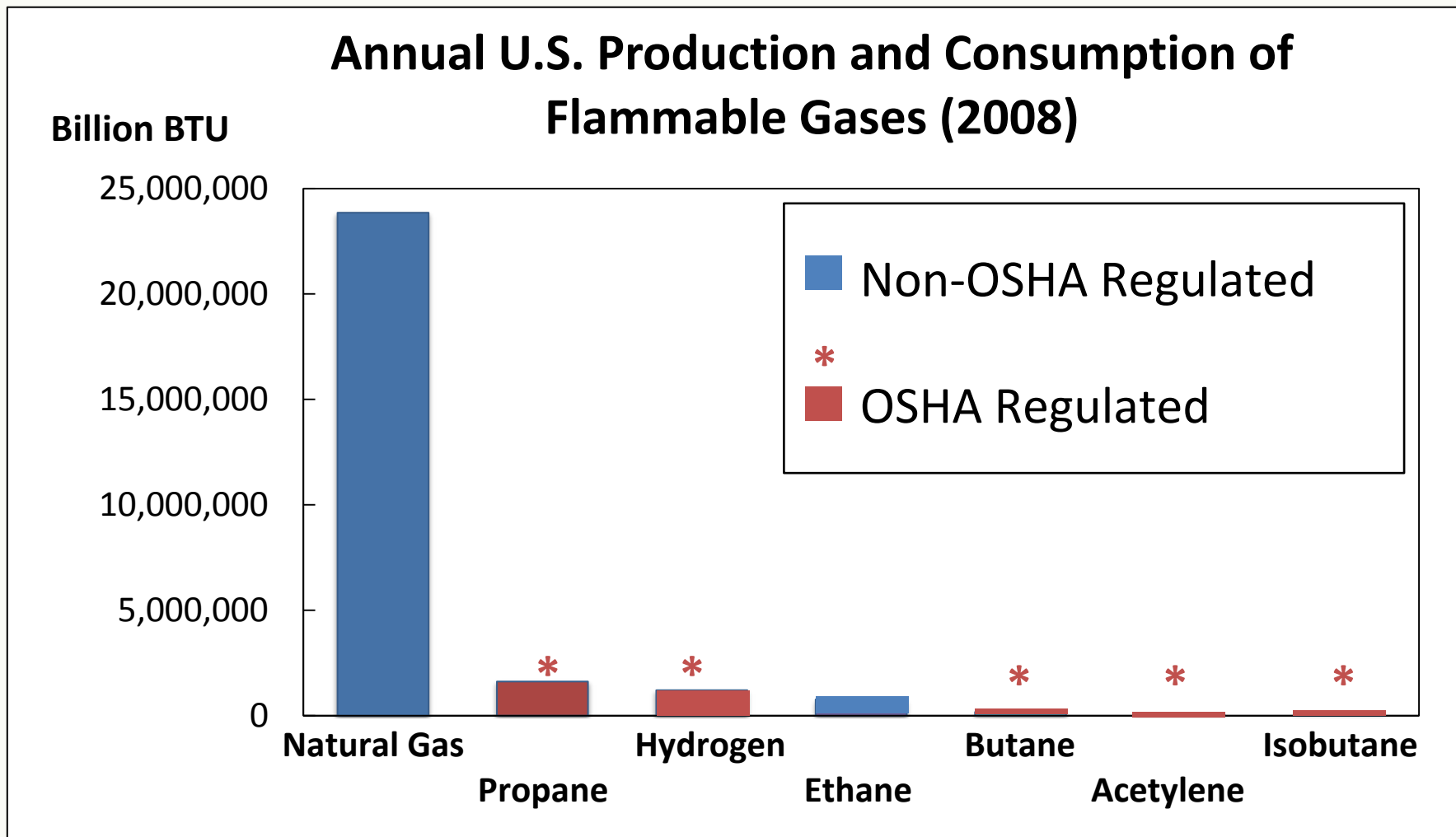
Other Standards Do Not Prohibit Natural Gas Blows

- **ASME B31.1**
 - Does not prohibit natural gas blows
- **FM Global’s “Natural Gas and Gas Piping”**
 - Allows for use of fuel gas to clean or test piping when the pressure is 0.5 psig or less

There are no standards and extremely limited guidance in regards to cleaning fuel gas piping



OSHA Does Not Regulate Natural Gas Usage





OSHA Regulations Contain Many Gaps

- **OSHA does not expressly prohibit the planned release of flammable gas in the vicinity of workers**
- **OSHA's PSM standard exempts flammable liquids or gases that are used solely for workplace fuel consumption**
- **OSHA does not require workers to participate in developing procedures or training related to fuel gas safety**



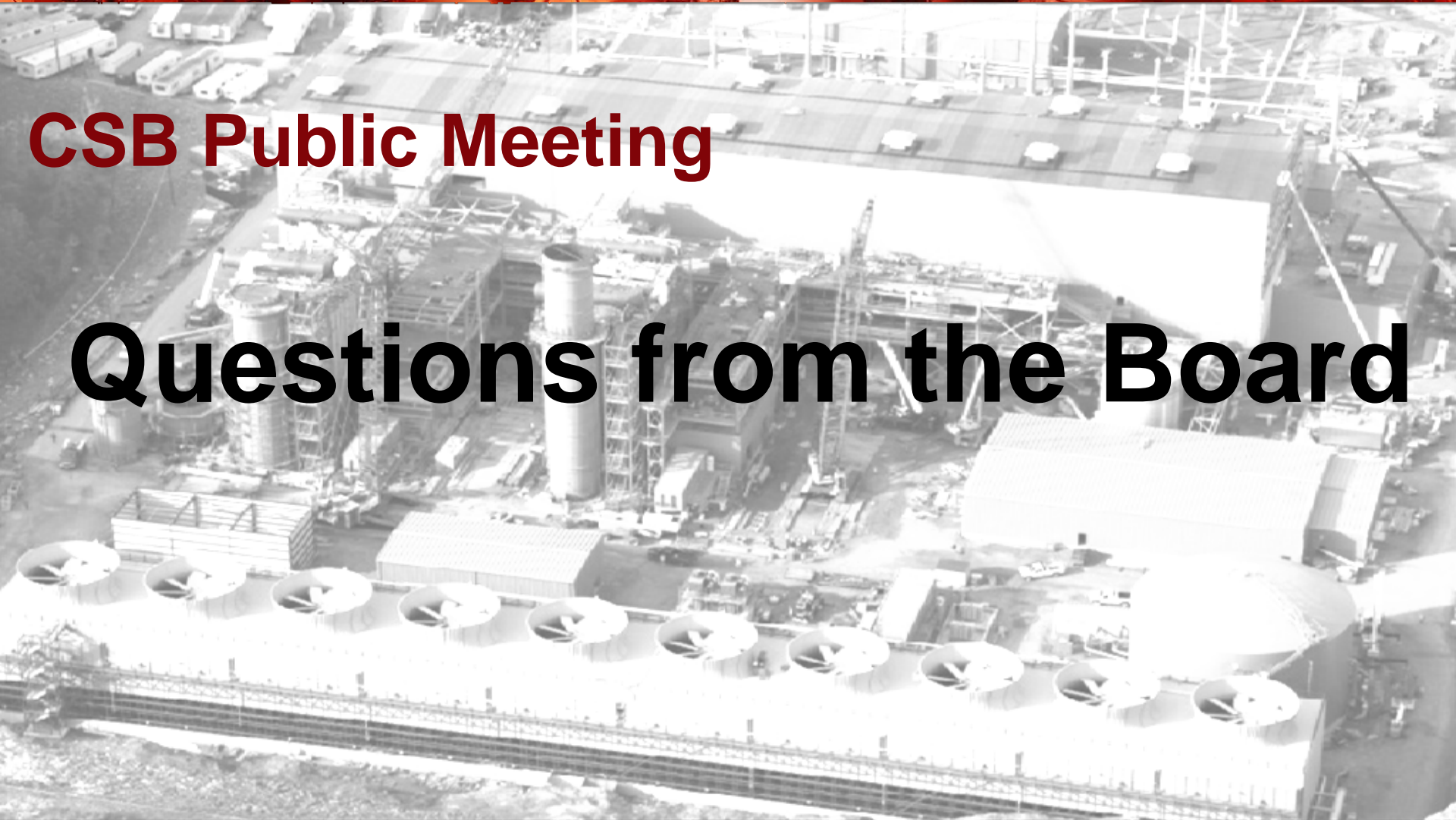
No Standards Specific to Power Generation Sector

- **The electric power sector and related industry associations currently:**
 - Do not operate a safety standards development program
 - Do not publish industry-recognized safety standards
 - Do not have recognized good practice safety standards or technical guidelines that address the cleaning of power plant fuel gas piping



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Questions from the Board





Proposed Urgent Recommendation

Occupational Safety and Health Administration (OSHA)

Promulgate regulations that address fuel gas safety for construction and general industry. At a minimum:

- **Prohibit the release of flammable gas to the atmosphere for the purpose of cleaning fuel gas piping**
- **Prohibit flammable gas venting or purging indoors. Prohibit venting or purging outdoors where fuel gas may form a flammable atmosphere in the vicinity of workers and/or ignition sources**



Proposed Urgent Recommendation

Occupational Safety and Health Administration (OSHA) continued

- **Prohibit any work activity in areas where the concentration of flammable gas exceeds a fixed low percentage of the lower explosive limit (LEL) determined by appropriate combustible gas monitoring**
- **Require that companies develop flammable gas safety procedures and training that involves contractors, workers, and their representatives in decision-making**



Proposed Urgent Recommendation

National Fire Protection Association (NFPA)

Enact a Tentative Interim Amendment as well as permanent changes to the National Fuel Gas Code that addresses the safe conduct of fuel gas piping cleaning operations. At a minimum:

- **Remove the existing NFPA 54 fuel gas piping exemptions for power plants and systems with an operating pressure of 125 psig or more**
- **For the cleaning methodology, require the use of inherently safer alternatives such as air blows or pigging with air in lieu of the use of flammable gas**



Proposed Urgent Recommendation

American Society of Mechanical Engineers

Make appropriate changes to the 2012 version of *Power Piping*, ASME B31.1 to require the inherently safer fuel gas piping cleaning methodologies rather than natural gas blows.

At a minimum:

- **For the cleaning or flushing methods discussed in B31.1 paragraph 122.10, require the use of inherently safer alternatives such as air blows and pigging with air as the motive force in lieu of the use of flammable gas**



Proposed Urgent Recommendation

Gas Turbine Manufacturers:

**General Electric, Siemens, Solar, Mitsubishi Power Systems,
Pratt & Whitney, and Rolls-Royce**

Provide to your customers:

- **Comprehensive technical guidance on inherently safer methods for cleaning fuel gas piping, such as the use of air or pigging with air**
- **Comprehensive Cleaning Force Ratio (CFR) guidelines, specifying both the upper and lower limits required, to obtain satisfactory cleaning for the fuel gas piping for purposes of the warranties of the turbines**
- **Warnings against the use of fuel gas to clean pipes**



Proposed Urgent Recommendation

Gas Turbine Manufacturers:

**General Electric, Siemens, Solar, Mitsubishi Power Systems,
Pratt & Whitney, and Rolls-Royce**

Work with the Electric Power Research Institute to publish technical guidance addressing the safe cleaning of fuel gas piping supplying gas turbines. At minimum:

- **For cleaning methodology, require the use of inherently safer alternatives such as air blows and pigging with air in lieu of flammable gas**
- **Provide technical guidance for the safe and effective use of alternative methods for cleaning such as air and pigging with air.**



Proposed Urgent Recommendation

The Governor and Legislature of the State of Connecticut

- **Enact legislation applicable to power plants in the state that prohibits the use of flammable gas that is released to the atmosphere to clean fuel gas piping**
- **Adopt the current version of NFPA 54 as amended pursuant to our previous recommendation**
- **Send correspondence to the governors of the other 49 states, urging them to review the findings of the Kleen investigation and the recommendations made to Connecticut**



Proposed Urgent Recommendation

Electric Power Research Institute (EPRI):

Work with the six turbine manufacturers we identified to publish technical guidance addressing the safe cleaning of fuel gas piping supplying gas turbines. At minimum:

- **For the cleaning methodology, require the use of inherently safer alternatives such as air blows and pigging with air in lieu of the use of flammable gas.**
- **Provide comprehensive technical guidance on inherently safer methods for cleaning fuel gas piping, such as the use of air or pigging with air.**



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