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Technical Committee on Electric Generating Plants (ECG-AAA)

MEMORANDUM

DATE: March 22, 2019

TO: Principal and Alternate Technical Committee Members

FROM: Brian O'Connor, NFPA Staff Liaison
Office: (617) 984-7257 Email: BOConnor@NFPA.org

SUBJECT: **AGENDA – NFPA 850 and NFPA 853 Second Draft Meeting (Fall 2019) April 2-4, 2019, Savannah, GA**

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1. Call to Order – April 2, 2019, 8:00am ET
2. Introductions and Attendance (Attachment A)
3. NFPA Staff Liaison Presentation
4. Chairman Comments
5. Approval of Previous Meeting Minutes (Attachment B)
6. Task Group Reports (Attachment C)
    a. Conveyors Task Group – Don Birchler/Bob Taylor
    b. Steam and Combustion Turbines Task Group – Larry Danner
    c. New Technology Task Group – Rickey Johnson
    d. Chapter 11 Task Group – Rickey Johnson
7. Act on Public Input and Generate First Revisions for NFPA 850 (41 Public Inputs Received) (Attachment D)
8. Act on Public Input and Generate First Revisions for NFPA 853 (3 Public Inputs Received) (Attachment E)
9. Other Business
10. Next Meeting
11. Adjourn Meeting

Please submit requests for additional agenda items to the chair at least seven days prior to the meeting, and notify the chair and/or staff liaison as soon as possible if you plan to introduce any large-scale revisions at the meeting.

All NFPA Technical Committee meetings are open to the public. Please contact me for information on attending a meeting as a guest. Read NFPA's Regulations Governing the Development of NFPA Standards (Section 3.3.3.3) for further information.

Additional Meeting Information:
See the Meeting Notice on the Document Information Page (www.nfpa.org/850next or www.nfpa.org/853next) for meeting location details. If you have any questions, please feel free to contact **Sarah Caldwell**, *Technical Committee Administrator* at 617-984-7950 or by email SCaldwell@nfpa.org.

C. Standards Administration

Attachment A: Technical Committee Roster

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Attachment B: Previous Meeting Minutes

NFPA 850/853 – *Technical Committee on Electric Generating Plants*

First Draft Meeting Minutes

April 10th - 12th, 2018

Attendees

Mark Boone, *Chair*	Brian O'Connor, *Staff Liaison*

Principals

Steven Behrens	Daryl Bessa
Donald Birchler	Tom Clark
Larry Danner	Laurie Florence
Brian Ford	Daniel Groff
Paul Hayes	Fred Hildebrandt
Rickey Johnson	David Kipley
Marshall Clinton	Eric Prause
Scot Pruett	Richard Ryan
Robert Taylor	

Alternates

James Bouche	Dennis Mason
Larry Shackelford	Andrew Wolfe
Johnny Young	

Guests

Anne Goj, Transformer Protector Corp.	Lawrence Carmen, Victaulic

A three day meeting was held at the Embassy Suites in New Orleans, Louisiana.

1. Chairman Mark Boone called to the meeting to order at 8:00am on Tuesday April 10th, 2018

2. The committee and guests went around the room and introduced themselves

3. Chairman Mark Boone presented the Chairman's report. The following was discussed:
    a. Recent plant fires
    b. Update of committee roster
    c. Review the reorganization of NFPA 850

4. NFPA Staff Liaison, Brian O’Connor, gave a presentation outlining the schedule of the document, emergency procedures for the building and legal matters.

5. A representative from Transformer Corp gave a short presentation on Depressurization System technology to support Public Inputs they submitted.

6. The Technical Committee reviewed all of the Public Inputs submitted and reviewed the reorganization of the document.

7. The committee had a discussion on submitting recommended changes to related NFPA standards.

8. A new task group on flywheel and compressed air power generation was formed, led by Rickey Johnson

9. Meeting Adjourned 12:00PM on Thursday April 12th, 2018

Attachment C: Task Group Reports

Chapter 9 Fuels, Common Equipment and Protection

9.1 General.

The identification and selection of fire protection systems should be based on the Fire Protection Design Basis Document. This chapter identifies fire and explosion hazards in fossil fueled electric generating stations and specifies the recommended protection criteria unless the Fire Protection Design Basis Document indicates otherwise.

9.2 Flammable Gases.

9.3 Combustible Liquids

9.4 Flammable Liquids.

9.5 Solid Fuels

9.7 Hydraulic Control System.

9.9 Electrical Equipment.

9.10 Storage Rooms, Offices, and Shops.

9.11 Oil Storage Areas.

9.12 Warehouses.

9.13 Fire Pumps.

9.14 Cooling Towers.

9.15 Auxiliary Boilers.

9.16

Vehicle repair facilities should …

9.17 Air Compressors.

Commented [KD1]: Will Emergency Generators fall under this category, or should it have it's own sub title as well (Was 7.9.1)?

Commented [DL(P2R1]: Good point. I note that the text (now at 9.9.11 - last "piece" of section 9.9) is mostly a reference to NFPA 37 so picking it up and dropping it in to Chapter 10 would be simple, see my proposed location at 10.3.6 below

Chapter 10 Turbines, Generators and Internal Combustion Engines

10.1 General.

10.1.1

Chapter 10 identifies fire and explosion hazards of combustion turbine (CT) Steam turbine (ST) and internal combustion engine (ICE) electric generating units and specifies recommended protection criteria.

10.1.2

It should be recognized that some CT generating facilities consist of manufactured modules wherein construction consists of siting these modules, providing fuel supply, essential services, and interconnections to the electric system, while other facilities consist of buildings specifically designed and built or modified for the CT generator and its auxiliaries. Therefore, some recommendations might be more suitable for one type of plant than another.

10.1.3

ST generating facilities consist of turbine assemblies and auxiliary equipment wherein construction consists of incorporating these items into a boiler or HRSG steam system. Although the typical installation is in an open area within a dedicated turbine building, outdoor installations with weather enclosures for the turbine are known and acoustic enclosures may be incorporated for indoor units. As for the CT installations, some recommendations might be more suitable for one type of plant than another.

~~10.1.3*~~ 10.1.4*

Modern ICE generating equipment is typically provided as a complete package requiring only a fuel source and electrical connections to the system to be powered. The installations should be either fixed/permanent or installed as a portable/temporary power source. The recommendations of this chapter should be applied to fixed nonresidential installations only.

~~10.1.4~~ 10.1.5

Compressors and regulating stations installed on-site should be protected in accordance with the recommendations of Chapter 10.

10.2 Application of Chapters 4 through ~~10~~9.

The recommendations contained in Chapters 4 through ~~13~~ 9 can apply to ~~combustion~~ turbine electric generating units. The Fire Protection Design Basis Document will determine which recommendations apply to any specific CT, ST and ICE electric generating units. This determination is done by evaluating the specific hazards that exist in the facility and evaluating the level of acceptable risk for the facility. For large CT or ST units, or combined cycle plants, it is expected that most of the recommendations will apply, but for individually packaged CT and

Commented [KD3]: Although STs are typically part of a CT, I thought "ST" reference may be applicable in some cases and added text.

Commented [DL(P4R3]: Agree, I missed that detail here …

ICE units, many of the recommendations will not apply since the hazards described might not exist (e.g., small units might not have a cable spreading room or a warehouse).

10.3 ~~Combustion~~ Turbine and Internal Combustion Engine Generators.

10.3.1 General.

10.3.1.1

The installation and operation of CT and ICE generators should be in accordance with this chapter and NFPA 37.

10.3.1.2

Site-specific design considerations or manufacturer's typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the CTs, STs or ~~the~~ ICEs. The CT generator is frequently supplied as a complete power plant package with equipment mounted on skids or pads and provided with metal enclosures forming an all-weather housing. In addition to being weathertight, the enclosures are designed to provide thermal and acoustical insulation. ST generators are typically supplied as components that are incorporated into the power plant design and installed in an open room or separate building. Metal acoustic enclosures are available as options for some ST generators. Smaller ICE plants might involve enclosures for equipment, but more commonly engine generators are installed in a row in an open room or hall.

10.3.1.3*

The fire and explosion hazards associated with CT, ST and ICE electric generator units are as follows:

(1) Flammable and combustible fuels

(2) Hydraulic and lubricating oils

(3) Electrical and control equipment

(4) Filter media

(5) Combustible enclosure insulation

(6) Internal explosions in CTs

(7) Crankcase explosions in ICEs

~~10.3.3~~ 10.3.1.4 Prevention of External Fires.

~~10.3.3.1~~10.3.1.4.1*

Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as follows:

(1) If rigid metal piping is used, it should be designed with freedom to deflect with the unit, in any direction. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly on the unit. Properly designed metallic hose is an alternative for fuel, hydraulic, and lube oil lines in high vibration areas, between rigid pipe supply lines and manifolds in and at the points of entry at the engine interface.

(2) Rigid piping connected directly to the unit should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the machine. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that can excite its natural frequency.

(3) Welded pipe joints should be used where practical. Threaded couplings and flange bolts in fuel and oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Couplings should have a positive locking device to prevent unscrewing.

Covers 9.8.6(1)

(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Liquid level indicators should be listed and protected from impact.

(5) Where practical, lubricating oil lines should use guarded pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time. If this is not practical, noncombustible coverings (e.g., piping sleeves and/or tubing and flange guards) should be used to reduce the possibility of oil atomization and contact with hot surfaces with subsequent spray fires.

From 9.8.6(2)

From 9.8.6(5)

(6) If practical, fluid piping should ~~not~~ be clear of, shielded from or routed ~~above~~ below steam piping, hot metal parts, electrical equipment or other sources of ignition to preclude leaked fluid dripping on the equipment.

From 9.8.6(3)

(7) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

From 9.8.6(4)

~~9.6.2.1*~~ 10.3.1.4.2*

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler or foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.30 gpm/ft2 (12.2 mm/min) over a minimum application of 5000 ft2 (464 m2).

~~9.6.2.2~~ 10.3.1.4.3

Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 0.30 gpm/ft2 (12.2 mm/min).

~~9.6.2.3*~~ 10.3.1.4.4*

Protection for pedestal-mounted turbine generators with no operating floor can be provided by recommendations ~~9.6.2~~10.3.1.4 and by containing and drainage of oil spills and providing local automatic protection systems for the containment areas. In this type of layout, spray fires from lube oil and hydrogen seal oil conditioning equipment and from control oil systems using mineral oil, if released, could expose building steel or critical generating equipment. Additional protection such as enclosing the hazard, installing a noncombustible barrier between the hazard and critical equipment, or use of a water spray system over the hazard should be considered.

~~9.6.2.4*~~ 10.3.1.4.5*

Foam-water sprinkler systems installed in place of automatic sprinklers should be designed in accordance with NFPA 16, including the design densities specified in Chapter 9

~~9.6.2.5~~ 10.3.1.4.6

Electrical equipment in the area covered by a water or foam-water system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

~~10.3.3.2*~~ 10.3.1.4.7*

In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistant fluid should be considered. If separate systems are used, the hydraulic control system should use a listed fire-resistive hydraulic fluid, and a listed fire-resistant fluid should be considered for the lubricating system.

~~10.3.3.4~~ 10.3.1.4.8

For recommendations regarding containment and drainage of liquids, see Section 6.5.

~~10.3.3.5~~ 10.3.1.4.9

In order to prevent conditions that could cause a fire while the unit is operating, control packages should include the parameter monitoring and shutdown capabilities described in Chapter 9 of NFPA 37.

~~9.8~~ 10.3.1.5 Lubricating Oil Systems.

~~9.8.1*~~ 10.3.1.5.1*

Use of a listed fire resistant (i.e., less hazardous or less flammable) lubricating oil should be considered. The use of a listed fire-resistant fluid as a turbine-generator lubricating oil (see 7.8.2) could eliminate the need for fire protection beneath the operating floor, at lubricating oil lines, lubricating oil reservoir, and turbine-generator bearings to mitigate the hazard posed solely by pool and three-dimensional fires involving lubrication oil. Protection against pool and three-dimensional fires in accordance with 7.13.4.1 should be installed if the hydrogen seal oil system does not use listed fire-resistant fluids. Generator bearings for seal oil systems not using listed fire-resistant fluids should be protected in accordance with ~~9.6.2.6~~ 10.3.3.1. Stakeholders should be involved in the decision making process before eliminating fire protection for the turbine lubrication oil hazard.

~~9.8.2~~ 10.3.1.5.2

Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30.

~~9.8.3~~ 10.3.1.5.3

Lubricating oil reservoirs should be provided with a vapor extractor, vented to a safe outside location.

~~9.8.4~~ 10.3.1.5.4

Curbing or drainage or both should be provided for the lubricating oil reservoir in accordance with Section 6.5.

~~9.8.5~~ 10.3.1.5.5

All oil piping serving the turbine, ICE or generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration. (*See NFPA 30*.)

9.8.6*

Piping design and installation should consider the following protective measures:

(1) Welded construction

(2) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time

(3) Route oil piping so as to be clear of, shielded from, or below steam piping, hot metal parts, electrical equipment or other sources of ignition.

(4) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

(5) Noncombustible coverings (e.g., flange guards) around the flange to reduce the possibility of oil spraying onto a hot surface

Incorporated into 10.3.1.4.1

Commented [KD5]: So are you saying this should be deleted?

Commented [DL(P6R5]: Yes, included here to keep track of the information that I incorporated into 10.3.1.4.1 above, This will not show up in the "replaced" chapter attachment to be submitted in TerraView.

~~9.8.7~~ 10.3.1.5.6

Remote operation from the control room of the condenser vacuum break valve and shutdown of the lubricating oil pumps should be provided. Breaking the condenser vacuum markedly reduces the rundown time for the machine and thus limits oil discharge in the event of a leak. See the discussion in 5.4.6.1 on fire emergency planning involving turbine lubricating oil fires.

~~9.8.8~~ 10.3.1.5.7

Cable for operation of lube oil pumps should be protected from fire exposure. Protection can consist of separation of cable for ac and dc oil pumps or 1-hour fire resistive coating (derating of cable should be considered).

~~9.8.9~~ 10.3.1.5.8 Fire Protection.

~~9.8.9.1*~~ 10.3.1.5.8.1*

Lubricating oil reservoirs and handling equipment should be protected in accordance with **10.3.1.4.2.** If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system or a hybrid fire extinguishing system.

~~10.3.5~~ 10.3.1.6 Inlet Air System.

~~10.3.5.1*~~ 10.3.1.6.1*

Air filters and evaporative cooling media should be constructed from less flammable materials whenever practical. ANSI/UL 900, *Standard for Safety Test Performance of Air Filters, can be used as guidance*.

~~10.3.5.2~~ 10.3.1.6.2

Manual fire-fighting equipment should be available to personnel performing maintenance on air filters.

~~10.3.5.3~~ 10.3.1.6.3

Access doors or hatches should be provided for manual fire fighting on large air filter structures.

~~10.3.7~~ 10.3.1.7 Starting Equipment for CTs.

Where ICEs or torque converters are used, fire protection should be provided based on consideration of the factors in 10.3.4.1.

10.3.2 Combustion Turbines

Make new, 10.3.3.3 is source

~~10.3.3.3~~ 10.3.2.1

Combustible gas detector(s) should be considered for the CT enclosures.

~~10.3.4~~ 10.3.2.2 Fire Protection ~~for Combustion Turbines and Internal Combustion Electrical Generators.~~

~~10.3.4.1~~ 10.3.2.2.1

Commented [KD7]: Should this be deleted, since the discussion is for ICE as well?

Commented [DL(P8R7]: No, some combustion turbines use an ICE as the starting means, this clause addresses that specific use of the ICE. This use, while is generically covered in NFPA 37 is really part of the turbine installation so it deserves a bit of attention here. Steam turbines are started by simply flowing steam to the unit.

Commented [KD9]: Should we refer to Chapter 7 for any FP discussions?

Commented [DL(P10R9]: Concur for general requirements; however, there are some equipment specific issues that should exist in this chapter and "amend" the general requirements. For example, the installation of deluge water spray for a steam turbine bearing must be done with care so as to avoid serious internal damage to the turbine from the casing "shrinking" from the cooling effect of the water causing hard blade rubs with the still spinning rotor – discussed more below at 10.3.3.1.2. Adding explanatory text consistent with this thought

Determination of the need for fire suppression for combustion turbines should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance.

~~10.3.4.1.1~~ 10.3.2.2.1.1

Fire system operation should be arranged to close the fuel valves ~~except for ICE emergency power supply systems (e.g., hospital emergency power)~~.

~~10.3.2~~ 10.3.2.3 Prevention of Internal Explosions in Combustion Turbines.

~~10.3.2.1*~~ 10.3.2.3.1*

Combustion turbines should have a proof-of-flame detection system in the combustion section to detect flameout during operation or ignition failure during startup. In the case of flameout, the fuel should be rapidly shut off. If ignition is not achieved within a normal startup time, then the control system should abort the startup and close the fuel valves.

~~10.3.2.2~~ 10.3.2.3.2

Two safety shutoff valves in series on the main fuel line should be used to minimize the likelihood of fuel leaking into the engine. On gas systems an automatic vent to the outside atmosphere should be provided between the two valves.

~~10.4.2~~ 10.3.3 Steam Turbines.

Steam turbines, and their associated hazards should be designed and protected in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.1.4.2 through 10.3.1.4.8.

~~9.6.2.6*~~ 10.3.3.1* Bearings.

~~9.6.2.6.1*~~ 10.3.3.1.1*

Turbine bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles or water spray or water mist systems. Automatic actuation is more reliable than manual action. Water spray and sprinkler systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft2 (10.2 mm/min) over the protected area of all bearings.

~~9.6.2.6.2~~ 10.3.3.1.2

Where enclosures are provided, compressed air foam systems and hybrid fire-extinguishing systems can be considered.

~~9.6.2.6.3*~~ 10.3.3.1.3*

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Commented [DL(P12R11]: Yes, reconfirming the Section 7.6 basis.

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Commented [KD13]: This is addressed in Section 7.6.2.7. Is this redundant?

Commented [DL(P14R13]: This provides additional specific installation guidance to mitigate potential thermal induced damage to the machine as discussed in my comment above.

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Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be permitted to be protected by shields and encasing insulation with metal covers.

10.3.4 Internal Combustion Engines

10.3.3.3 10.3.4.1

Make new, 10.3.3.3 is source

Combustible gas detector(s) should be considered for the ICE enclosures.

10.3.4 10.3.4.2 Fire Protection

10.3.4.1 10.3.4.2.1

Determination of the need for fire suppression for the internal combustion engine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance.

10.3.4.1.1 10.3.4.3

Fire system operation should be arranged to close the fuel valves except for ICE emergency power supply systems (e.g., hospital emergency power).

10.3.1.4 10.3.4.4

In the event of a problem with older ICEs, shutdown might be difficult. Several different methods, operating independently, should be provided. These methods can include centrifugally tripped (overspeed condition) spring-operated fuel rack closure, governor fuel rack closure, electropneumatic fuel rack closure, or air inlet guillotine–type air shutoff.

10.3.6 10.3.5 Generators.

10.3.6.1

Hydrogen systems should comply with recommendations in 9.6.1 and 9.6.2.8.

Replaced with moved text

9.6.1 10.3.5.1 Hydrogen System Cooled Generators.

9.6.1.1* General.

9.6.1.1.1 10.3.5.1.1*

Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable either by "dead man" type controls at the generator fill point(s) or operable from the control room. This would minimize the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant. Alternatively, vented guard piping can be used in the building to protect runs of hydrogen piping.

9.6.1.1.2 10.3.5.1.2

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Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.

~~9.6.1.1.3~~ 10.3.5.1.3

Hydrogen cylinders and generator hydrogen fill and purge manifold should be located remote from the turbine generator.

~~9.6.1.1.4~~ 10.3.5.1.4

For electrical equipment in the vicinity of the hydrogen handling equipment, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code*.

~~9.6.1.2~~ 10.3.5.2 Hydrogen Seal Oil System.

~~9.6.1.2.1~~ 10.3.5.2.1

Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

~~9.6.1.2.2~~ 10.3.5.2.2

Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire-retardant coating if exposed in the area of the turbine generator to minimize possibility of loss of both pumps as a result of a turbine generator fire.

~~9.6.2.8~~ 10.3.5.2.3 ~~Hydrogen Seal Oil.~~

Hydrogen seal oil units should be protected in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.1.4.2 through 10.3.1.4.6.

~~9.6.1.3~~ 10.3.5.3

Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 6.5.

~~9.6.1.4~~ 10.3.5.4

A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply where the generator is opened for maintenance.

~~9.6.1.5~~ 10.3.5.5

For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code*.

~~9.6.1.6~~ 10.3.5.6

Commented [KD17]: Suggest referring to 7.6?

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Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.

~~9.6.1.7~~ 10.3.5.7

Hydrogen lines should not be piped into the control room.

~~9.6.1.8~~ 10.3.5.8

The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or an area accessible during a machine fire.

~~10.3.6.2~~ 10.3.5.9

Fire protection should be provided in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.3.1 for turbine bearings and 10.3.1.4.2 through 10.3.1.4.5 for oil piping or any area where oil can flow, accumulate, or spray.

~~9.6.2.7~~ 10.3.5.9.1

Exciter. The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

~~10.3.6.3*~~ 10.3.5.10*

Air-cooled generators should be tightly sealed against the ingress of moisture in the event of discharge (accidental or otherwise) of a water spray system. Sealing should be positive, such as by a gasket or grouting, all around the generator housing.

~~9.9.11~~ 10.3.6 Emergency Generators.

~~9.9.11.1~~ 10.3.6.1

The installation and operation of emergency generators should be in accordance with NFPA 37.

~~9.9.11.2~~ 10.3.6.2 Fire Protection.

~~9.9.11.2.1~~ 10.3.6.2.1

Emergency generators located within main plant structures should be protected in accordance with NFPA 37.

~~9.9.11.2.2~~ 10.3.6.2.2

Where gaseous suppression systems are used on combustion engines that can be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.

10.4 Combined Cycle Units.

Commented [KD19]: Refer to Section 7.6? this seems redundant.

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10.4.1 Heat Recovery Steam Generators.

Heat recovery steam generators using supplemental firing should be designed and protected in accordance with Section 7.5. (*See NFPA 85 for additional requirements*.)

Chapter 9 Fuels, Common Equipment and Protection

9.1 General.

The identification and selection of fire protection systems should be based on the Fire Protection Design Basis Document. This chapter identifies fire and explosion hazards in fossil fueled electric generating stations and specifies the recommended protection criteria unless the Fire Protection Design Basis Document indicates otherwise.

9.2 Flammable Gases.

9.3 Combustible Liquids

9.4 Flammable Liquids.

9.5 Solid Fuels

9.6 Turbine-Generator. ← Completely incorporated into Chapter 10

9.7 Hydraulic Control System.

9.8 Lubricating Oil Systems. ← Completely incorporated into Chapter 10

9.9 Electrical Equipment. ← 9.9.11 Emergency Generators moved to Chapter 10

9.10 Storage Rooms, Offices, and Shops.

9.11 Oil Storage Areas.

9.12 Warehouses.

9.13 Fire Pumps.

9.14 Cooling Towers.

9.15 Auxiliary Boilers.

9.16

Vehicle repair facilities should …

9.17 Air Compressors.

Chapter 10 Turbines, Generators and Internal Combustion Engines

10.1 General.

10.1.1

Chapter 10 identifies fire and explosion hazards of combustion turbine (CT) Steam turbine (ST) and internal combustion engine (ICE) electric generating units and specifies recommended protection criteria.

10.1.2

It should be recognized that some CT generating facilities consist of manufactured modules wherein construction consists of siting these modules, providing fuel supply, essential services, and interconnections to the electric system, while other facilities consist of buildings specifically designed and built or modified for the CT generator and its auxiliaries. Therefore, some recommendations might be more suitable for one type of plant than another.

10.1.3

ST generating facilities consist of turbine assemblies and auxiliary equipment wherein construction consists of incorporating these items into a boiler or HRSG steam system. Although the typical installation is in an open area within a dedicated turbine hall, outdoor installations with weather enclosures for the turbine are known and acoustic enclosures may be incorporated for indoor units. Similar to CT installations, some recommendations might be more suitable for one type of plant than another.

~~10.1.3*~~ 10.1.4*

Modern ICE generating equipment is typically provided as a complete package requiring only a fuel source and electrical connections to the system to be powered. The installations should be either fixed/permanent or installed as a portable/temporary power source. The recommendations of this chapter should be applied to fixed nonresidential installations only.

~~10.1.4~~ 10.1.5

Compressors and regulating stations installed on-site should be protected in accordance with the recommendations of Chapter 10.

10.2 Application of Chapters 4 through 9.

The recommendations contained in Chapters 4 through 9 can apply to ~~combustion~~ turbine electric generating units. The Fire Protection Design Basis Document will determine which recommendations apply to any specific CT, ST and ICE electric generating units. This determination is done by evaluating the specific hazards that exist in the facility and evaluating the level of acceptable risk for the facility. For large CT or ST units, or combined cycle plants, it is expected that most of the recommendations will apply, but for individually packaged CT and

ICE units, many of the recommendations will not apply since the hazards described might not exist (e.g., small units might not have a cable spreading room or a warehouse).

10.3 ~~Combustion~~ Turbine and Internal Combustion Engine Generators.

10.3.1 General.

10.3.1.1

The installation and operation of CT and ICE generators should be in accordance with this chapter and NFPA 37.

10.3.1.2

Site-specific design considerations or manufacturer's typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the CTs, STs or ~~the~~ ICEs. The CT generator is frequently supplied as a complete power plant package with equipment mounted on skids or pads and provided with metal enclosures forming an all-weather housing. In addition to being weathertight, the enclosures are designed to provide thermal and acoustical insulation. ST generators are typically supplied as components that are incorporated into the power plant design and installed in an open room or hall. Metal acoustic enclosures are available as options for some ST generators. Smaller ICE plants might involve enclosures for equipment, but more commonly engine generators are installed in a row in an open room or hall.

10.3.1.3*

The fire and explosion hazards associated with CT, ST and ICE electric generator units are as follows:

(1) Flammable and combustible fuels

(2) Hydraulic and lubricating oils

(3) Electrical and control equipment

(4) Filter media

(5) Combustible enclosure insulation

(6) Internal explosions in CTs

(7) Crankcase explosions in ICEs

~~10.3.3~~ 10.3.1.4 Prevention of External Fires.

~~10.3.3.1~~ 10.3.1.4.1* ← Annex material from 9.8.6 now tagged here

Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as follows:

(1) If rigid metal piping is used, it should be designed with freedom to deflect with the unit, in any direction. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly on the unit. Properly designed metallic hose is an alternative for fuel, hydraulic, and lube oil lines in high vibration areas, between rigid pipe supply lines and manifolds in and at the points of entry at the engine interface.

(2) Rigid piping connected directly to the unit should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the machine. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that can excite its natural frequency.

(3) Welded pipe joints should be used where practical. Threaded couplings and flange bolts in fuel and oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Couplings should have a positive locking device to prevent unscrewing.

Covers 9.8.6(1)

(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Liquid level indicators should be listed and protected from impact.

(5) Where practical, lubricating oil lines should use guarded pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time. If this is not practical, Noncombustible coverings (e.g., piping sleeves and/or tubing and flange guards) should be used to reduce the possibility of oil atomization and contact with hot surfaces with subsequent spray fires.

From 9.8.6(2)

From 9.8.6(5)

(6) If practical, fluid piping should ~~not~~ be clear of, shielded from or routed ~~above~~ below steam piping, hot metal parts, electrical equipment or other sources of ignition to preclude leaked fluid dripping on the equipment.

From 9.8.6(3)

(7) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

From 9.8.6(4)

~~9.6.2.1*~~ 10.3.1.4.2*

Annex material from 9.6.2.1 now tagged here

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler or foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.30 gpm/ft2 (12.2 mm/min) over a minimum application of 5000 ft2 (464 m2).

~~9.6.2.2~~ 10.3.1.4.3

Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 0.30 gpm/ft2 (12.2 mm/min).

~~9.6.2.3*~~ 10.3.1.4.4* ← Annex material from 9.6.2.3 now tagged here

Protection for pedestal-mounted turbine generators with no operating floor can be provided by recommendations 9.6.2 and by containing and drainage of oil spills and providing local automatic protection systems for the containment areas. In this type of layout, spray fires from lube oil and hydrogen seal oil conditioning equipment and from control oil systems using mineral oil, if released, could expose building steel or critical generating equipment. Additional protection such as enclosing the hazard, installing a noncombustible barrier between the hazard and critical equipment, or use of a water spray system over the hazard should be considered.

~~9.6.2.4*~~ 10.3.1.4.5* ← Annex material from 9.6.2.4 now tagged here

Foam-water sprinkler systems installed in place of automatic sprinklers should be designed in accordance with NFPA 16, including the design densities specified in Chapter 9

~~9.6.2.5~~ 10.3.1.4.6

Electrical equipment in the area covered by a water or foam-water system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

~~10.3.3.2*~~ 10.3.1.4.7*

In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistant fluid should be considered. If separate systems are used, the hydraulic control system should use a listed fire-resistive hydraulic fluid, and a listed fire-resistant fluid should be considered for the lubricating system.

~~10.3.3.4~~ 10.3.1.4.8

For recommendations regarding containment and drainage of liquids, see Section 6.5.

~~10.3.3.5~~ 10.3.1.4.9

In order to prevent conditions that could cause a fire while the unit is operating, control packages should include the parameter monitoring and shutdown capabilities described in Chapter 9 of NFPA 37.

~~9.8~~ 10.3.1.5 Lubricating Oil Systems.

~~9.8.1*~~ 10.3.1.5.1*

Use of a listed fire resistant (i.e., less hazardous or less flammable) lubricating oil should be considered. The use of a listed fire-resistant fluid as a turbine-generator lubricating oil (see 7.8.2) could eliminate the need for fire protection beneath the operating floor, at lubricating oil lines, lubricating oil reservoir, and turbine-generator bearings to mitigate the hazard posed solely by pool and three-dimensional fires involving lubrication oil. Protection against pool and three-dimensional fires in accordance with 7.13.4.1 should be installed if the hydrogen seal oil system does not use listed fire-resistant fluids. Generator bearings for seal oil systems not using listed fire-resistant fluids should be protected in accordance with ~~9.6.2.6~~ 10.3.3.1. Stakeholders should be involved in the decision making process before eliminating fire protection for the turbine lubrication oil hazard.

~~9.8.2~~ 10.3.1.5.2

Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30.

~~9.8.3~~ 10.3.1.5.3

Lubricating oil reservoirs should be provided with a vapor extractor, vented to a safe outside location.

~~9.8.4~~ 10.3.1.5.4

Curbing or drainage or both should be provided for the lubricating oil reservoir in accordance with Section 6.5.

~~9.8.5~~ 10.3.1.5.5

All oil piping serving the turbine~~-~~ ICE or generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration. (*See NFPA 30*.)

9.8.6*

Piping design and installation should consider the following protective measures:

(1) Welded construction

(2) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time

(3) Route oil piping so as to be clear of, shielded from, or below steam piping, hot metal parts, electrical equipment or other sources of ignition.

(4) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

(5) Noncombustible coverings (e.g., flange guards) around the flange to reduce the possibility of oil spraying onto a hot surface

Incorporated into 10.3.1.4.1 above, left this here for transparency of the move.

~~9.8.7~~ 10.3.1.5.6

Remote operation from the control room of the condenser vacuum break valve and shutdown of the lubricating oil pumps should be provided. Breaking the condenser vacuum markedly reduces the rundown time for the machine and thus limits oil discharge in the event of a leak. See the discussion in 5.4.6.1 on fire emergency planning involving turbine lubricating oil fires.

~~9.8.8~~ 10.3.1.5.7

Cable for operation of lube oil pumps should be protected from fire exposure. Protection can consist of separation of cable for ac and dc oil pumps or 1-hour fire resistive coating (derating of cable should be considered).

~~9.8.9~~ 10.3.1.5.8 Fire Protection.

~~9.8.9.1*~~ 10.3.1.5.8.1*

Annex material from 9.8.9.1 now tagged here

Lubricating oil reservoirs and handling equipment should be protected in accordance with ~~9.6.2.1~~ 10.3.1.4.2. If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system or a hybrid fire extinguishing system.

~~10.3.5~~ 10.3.1.5 Inlet Air System.

~~10.3.5.1*~~ 10.3.1.5.1*

Air filters and evaporative cooling media should be constructed from less flammable materials whenever practical. ANSI/UL 900, *Standard for Safety Test Performance of Air Filters, can be used as guidance*.

~~10.3.5.2~~ 10.3.1.5.2

Manual fire-fighting equipment should be available to personnel performing maintenance on air filters.

~~10.3.5.3~~ 10.3.1.5.3

Access doors or hatches should be provided for manual fire fighting on large air filter structures.

~~10.3.7~~ 10.3.1.6 Starting Equipment for CTs.

Where ICEs or torque converters are used, fire protection should be provided based on consideration of the factors in 10.3.4.1.

10.3.2 Combustion Turbines

~~10.3.3.3~~ 10.3.2.1

Combustible gas detector(s) should be considered for the CT ~~and ICE~~ enclosures.

~~10.3.4~~ 10.3.2.2 Fire Protection ~~for Combustion Turbines and Internal Combustion Electrical Generators.~~

~~10.3.4.1~~ 10.3.2.2.1

Determination of the need for fire suppression for the combustion turbine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance

~~10.3.4.1.1~~ 10.3.2.2.2

Fire system operation should be arranged to close the fuel valves ~~except for ICE emergency power supply systems (e.g., hospital emergency power)~~.

~~10.3.2~~ 10.3.2.3 Prevention of Internal Explosions in Combustion Turbines.

~~10.3.2.1*~~ 10.3.2.3.1*

Combustion turbines should have a proof-of-flame detection system in the combustion section to detect flameout during operation or ignition failure during startup. In the case of flameout, the fuel should be rapidly shut off. If ignition is not achieved within a normal startup time, then the control system should abort the startup and close the fuel valves.

~~10.3.2.2~~ 10.3.2.3.2

Two safety shutoff valves in series on the main fuel line should be used to minimize the likelihood of fuel leaking into the engine. On gas systems an automatic vent to the outside atmosphere should be provided between the two valves.

~~10.4.2~~ 10.3.3 Steam Turbines.

Steam turbines~~, generators,~~ and their associated hazards should be designed and protected in accordance with ~~Section 9.6~~ an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.1.4.2 through 10.3.1.4.8.

~~9.6.2.6*~~ 10.3.3.1* ~~Turbine-Generator~~ Bearings. ← Annex material from 9.6.2.6 now tagged here

~~9.6.2.6.1*~~ 10.3.3.1.2* ← Annex material from 9.6.2.6.1 now tagged here

Turbine-generator bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles or water spray or water mist systems. Automatic actuation is more reliable than manual action. Water spray and sprinkler systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft2 (10.2 mm/min) over the protected area of all bearings.

~~9.6.2.6.2~~ 10.3.3.1.2

Where enclosures are provided, compressed air foam systems and hybrid fire-extinguishing systems can be considered.

~~9.6.2.6.3*~~ 10.3.3.1.3* ← Annex material from 9.6.2.6.3 now tagged here

Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be permitted to be protected by shields and encasing insulation with metal covers.

10.3.4 Internal Combustion Engines

~~10.3.3.3~~ 10.3.4.1

Combustible gas detector(s) should be considered for the ~~CT and~~ ICE enclosures.

~~10.3.4~~ 10.3.4.2 Fire Protection ~~for Combustion Turbines and Internal Combustion Electrical Generators.~~

~~10.3.4.1~~ 10.3.4.2.1

Determination of the need for fire suppression for the ~~combustion turbine~~ internal combustion engine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance.

~~10.3.4.1.1~~ 10.3.4.3

Fire system operation should be arranged to close the fuel valves except for ICE emergency power supply systems (e.g., hospital emergency power).

Made a conscious decision to be a bit repetitive here in the name of readability and organization

~~10.3.1.4~~ 10.3.4.4

In the event of a problem with older ICEs, shutdown might be difficult. Several different methods, operating independently, should be provided. These methods can include centrifugally tripped (overspeed condition) spring-operated fuel rack closure, governor fuel rack closure, electropneumatic fuel rack closure, or air inlet guillotine–type air shutoff.

~~10.3.6~~ 10.3.5 Generators.

~~10.3.6.1~~

~~Hydrogen systems should comply with recommendations in 9.6.1 and 9.6.2.8.~~

~~9.6.1~~ 10.3.5.1 Hydrogen ~~System~~ Cooled Generators.

~~9.6.1.1* General.~~

~~9.6.1.1.1~~ 10.3.5.1.1*

Annex material from 9.6.1.1 now tagged here

Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable either by “dead man” type controls at the generator fill point(s) or operable from the control room. This would minimize the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant. Alternatively, vented guard piping can be used in the building to protect runs of hydrogen piping.

9.6.1.1.2 10.3.5.1.2

Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.

9.6.1.1.3 10.3.5.1.3

Hydrogen cylinders and generator hydrogen fill and purge manifold should be located remote from the turbine generator.

9.6.1.1.4 10.3.5.1.4

For electrical equipment in the vicinity of the hydrogen handling equipment, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code*.

9.6.1.2 10.3.5.2 Hydrogen Seal Oil Pumps System.

9.6.1.2.1 10.3.5.2.1

Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

9.6.1.2.2 10.3.5.2.2

Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire-retardant coating if exposed in the area of the turbine generator to minimize possibility of loss of both pumps as a result of a turbine generator fire.

9.6.2.8 10.3.5.2.3 Hydrogen Seal Oil.

Hydrogen seal oil units should be protected in accordance with 9.6.2 an appropriate method selected from section 7.6 and considering the guidance provided in 10.3.1.4.2 through 10.3.1.4.6.

9.6.1.3 10.3.5.3

Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 6.5.

9.6.1.4 10.3.5.4

A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply where the generator is opened for maintenance.

9.6.1.5 10.3.5.5

For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code*.

9.6.1.6 10.3.5.6

Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.

9.6.1.7 10.3.5.7

Hydrogen lines should not be piped into the control room.

9.6.1.8 10.3.5.8

The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or an area accessible during a machine fire.

10.3.6.2 10.3.5.9

Fire protection should be provided in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.4 10.3.3.1 for generator turbine bearings and 10.3.1.4.2 through 10.3.1.4.5 for oil piping or any area where oil can flow, accumulate, or spray.

9.6.2.7 10.3.5.9.1

Exciter. The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

10.3.6.3* 10.3.5.10*

Air-cooled generators should be tightly sealed against the ingress of moisture in the event of discharge (accidental or otherwise) of a water spray system. Sealing should be positive, such as by a gasket or grouting, all around the generator housing.

9.9.11 10.3.6 Emergency Generators.

9.9.11.1 10.3.6.1

The installation and operation of emergency generators should be in accordance with NFPA 37.

9.9.11.2 10.3.6.2 Fire Protection.

9.9.11.2.1 10.3.6.2.1

Emergency generators located within main plant structures should be protected in accordance with NFPA 37.

9.9.11.2.2 10.3.6.2.2

Where gaseous suppression systems are used on combustion engines that can be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.

10.4 Combined Cycle Units.

10.4.1 Heat Recovery Steam Generators.

Heat recovery steam generators using supplemental firing should be designed and protected in accordance with Section 7.5. (*See NFPA 85 for additional requirements*.)

NOTE regarding Annex material: No “text” changes were made to the Annex items, only associated changes to the reference paragraph numbers.

1X.1 General.

1X.1.1 Chapter 1X identifies fire and explosion hazards of flywheel energy storage systems and associated equipment and specifies recommended protection criteria.

1X.1.2 Flywheel energy storage systems are energy storage systems composed of a spinning mass referred to as a rotor, rotor bearings, a motor-generator to convert the mechanical energy to electrical energy and power conversion system to convert the electrical energy to a form usable by the grid, and a protective housing to contain the rotating portions of the system. There are other balance of plant components including controls and monitoring equipment, a vacuum system to reduce effects of friction on the rotor and cooling systems to reduce the heat that develops from the operation of the rotor. There are primarily two types of rotor constructions, solid metal mass design and composite fiber design. The rotor stresses, rotor-dynamic behavior and operating conditions are dependent a combination of parameters. These parameters include rotor construction, the speed of rotation and must be engineered to assure a safe and reliable operation. There are also several different types of bearing constructions: a mechanical bearing design, a magnetic bearing design and a hybrid mechanical/magnetic bearing design. The magnetic bearings can use passive type using magnets, or active type that uses a controlled magnetic field that can be varied depending upon the forces acting on the rotor.

1X.1.3 Flywheel energy storage facilities consist of a number of flywheel energy storage systems with electrical outputs tied together with the electrical power voltage stepped up to match grid voltage. The particular design of the flywheel energy storage systems can vary as noted, as will that of the configuration of the power output circuitry and components. Therefore, some recommendations might be more suitable for one type of flywheel energy storage system facility than another. Many of the specific guidelines herein might require modification after due consideration of all local factors involved. The emphasis of this guideline is on prevention of fire by design with the addition of fire suppression equipment to be guided by the Fire Protection Design Basis Document as well as a cost-benefit analysis to determine the extent to which fire protection is justified.

1X.2 Application of Chapters 4 through 9.

The recommendations contained in Chapters 4 through 9 can apply to flywheel energy storage system facilities. The Fire Protection Design Basis Document should determine which recommendations apply to any specific flywheel energy storage system or facility. This determination is done by evaluating the specific hazards that exist in the facility and evaluating the level of acceptable risk for the facility. For flywheel energy storage facilities, it is expected that most of the recommendations will apply, although there could be particular flywheel energy storage systems and output circuit designs for which some of the recommendations will not apply since the hazards described might not exist (e.g., no transformer in the flywheel systems).

1X.3* Design and Equipment Arrangement.

A1X.3 For additional guidance on flywheel design and safety considerations refer to Sandia Report SAND2015-10759 Recommended Practices for the Safe Design and Operation of Flywheels.

1X.3.1 Site-specific considerations or a manufacturer's typical layout will govern flywheel energy storage system facility design. This will include the flywheel energy storage system design and containment system, power output, and load control circuitry. This will dictate how many separate structures or enclosures will be provided. The flywheel energy storage units and associated equipment may be installed outdoors or within buildings.

1X.3.2 Flywheel energy storage systems should be provided with a means for containment of the rotating mass to prevent access to the rotating parts and to contain debris that may result from abnormal operating conditions.

1X.3.3 Special-purpose electrical heaters can be used in flywheel energy storage systems to provide for oil sump and space heating. These heaters should be listed for the type of use in which they are employed.

1X.3.4 Vacuum or inert air systems are often used to reduce friction on moving parts and coolant systems may be employed to reject the heat from high speed rotating parts, motor/generators, and power converters..

1X.3.5 High speed rotating masses and their support bearings can create a large quantity of sparks if there is damage leading to abnormal friction from moving parts. The rotor housing should be designed to isolate any potential sparks from combustible equipment components and locations where leaked combustible fluids can accumulate.

1X.3.6 Particular care should be practiced with respect to spatial separation and protection from wildland fires as well as the control of vegetation where flywheel energy storage systems and associated equipment might be located. Guidance regarding vegetation clearance, separation distance, and emergency planning can be found in NFPA 1143 and NFPA 1144.

1X.4 Risk Consideration

1X.4.1 Adequate separation should be provided between the following, as determined by the Fire Protection Design Basis Document:
(1) Adjacent flywheel energy storage units consistent with land and wind topography constraints
(2) Adjacent structures or exposures, including transformers
(3) Adjacent properties (e.g., aboveground pipelines, tank farms, or natural gas facilities that could present a severe exposure)

1X.4.2 In the event of a problem with a flywheel energy storage system, automatic shutdowns or idling to bring the system to a safe state should be provided that result in slowing/stopping of shaft rotation, and/or isolation of electrical power to or from the motor/generator as dependent upon the system design. Different methods of equipment shutdown and isolation, operating independently, should be provided. These can include speed control as well as power isolation in concert with electronic control termination.

1X.4.3 Vacuum or inert gas systems employed to lower friction losses of rotating parts as well as cooling systems to prevent overheating of the flywheel motor/generators and their power converters should monitored and produce an orderly shutdown (i.e. spin down of the rotor) should these systems not be operating properly or fail.

1X.4.4 Determination of the need for fire detection/suppression and associated flywheel energy storage system safe shutdown sequence for flywheel energy storage system facilities should be based on the facility design and layout, including specific equipment and components used in producing power within the facility. The approach will vary also depending upon whether the flywheel energy storage system is located outdoors or indoors. This should be addressed in the Fire Protection Design Basis Document with regard to the flywheel energy storage units as well as power delivery and control circuits. In addition, consideration should be given to the consequences of failure of a flywheel energy storage unit or multiple units as well as the vulnerability of adjacent structures and equipment to damage.

1X.4.4.1 Should the Fire Protection Design Basis Document indicated in Chapter 4 determine a need for fire detection system(s), the system(s) should be arranged to activate alarms at a constantly attended location or via the provision of remote operator circuits. This applies to flywheel energy storage units, electrical equipment enclosures, and buildings.

1X.4.4.2 For remote location of flywheel energy storage facilities where there is a lack of abundant water supplies, the use of water-based fire protection systems is unlikely. If the design of a particular facility does, however, permit the use of water suppression systems, these systems should follow the general recommendations in Chapter 7. If the Fire Protection Design Basis Document indicates a need for fire-fighting capability using water, NFPA 1142 should be consulted.

1X.5 Hazard Protection

1X.5.1 In general, the principles outlined in NFPA 30 should be applied to gearboxes and lubricating or coolant oil sumps, pumps, coolers, filters, and associated piping. As a minimum, piping systems supplying flammable and combustible liquids should be designed to minimize hydraulic and lubricating oil piping failures as follows:

(1) If rigid metal piping is used, it should be designed with freedom to deflect with the gearbox, in any direction, at the interface with the gearbox. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly in the nacelle. Properly designed metallic hose is an alternative for hydraulic and lube oil lines in high vibration areas to allow relative motion between rigid pipe supply lines and manifolds, and at the points of entry at the gearbox and system interfaces.

(2) Rigid piping connected directly to the gearbox should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the gearbox, drive shaft and hub, and flywheel energy storage system. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that can excite its natural frequency.

(3) Welded pipe joints are preferred. Threaded couplings and flange bolts in oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Threaded fittings should have a positive locking device to prevent unscrewing.

(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Sight glasses should be listed.

(5) Lubricating oil lines should use “guarded” pipe construction with the pressure feed line located inside the return line. Where guarded pipe construction is not used, piping sleeves should be used to reduce the possibility of oil atomization. All mechanical connections should be guarded.

(6) Containment and drainage should be provided so as to minimize the spread of oil within the flywheel energy storage system or externally, which poses a risk to equipment.

(7) All fluid piping should be routed below all electrical equipment to preclude leaked fluid dripping on the equipment.

1X.5.2 Flywheel energy storage systems are to be provided with a means of containment for the rotating portion of the system to prevent exposure to sparks, projectiles, etc. in the event of a mechanical failure of the rotor and/or bearing assembly. A known scenario for mechanical failure that can lead to sparking and fire is rotor bearing failure resulting in a misplaced rotor in contact with non-moving parts such as the rotor shaft or the housing. In addition, the analysis of the flywheel system should document that the rotor assembly has a sufficient margin of safety factor between the strength of the rotor assembly design and the stresses to the system that occur under maximum normal operating conditions.

1X.5.3 For flywheel energy storage systems, monitors and/or trip functions should be provided to monitor and control the operation of flywheel energy storage systems safely, and initiate a safe state (e.g. spin down, idling condition) as dependent upon the system design, for abnormal operating conditions or parameters as noted below:
(1) Grid disturbance
(2)Abnormal condition (e.g. locking up, breakage, bearing damage) of rotor and/or bearings
(3) Abnormal vibration
(4) Loss of vacuum
(5) Loss of cooling
(6) Overheating of rotor assembly
(7) Overspeed
(8) Temperature faults (of critical components)
(9) Loss of/faulted magnetic field for magnetic bearings
(10) Oil condition (gearbox/lubrication and hydraulic)
(11) Motor-generator protection
(12) Loss of communication between flywheel energy storage units of a system or with control center
(13) Battery status
(14) Activation of smoke or heat detectors or sensors detecting abnormal conditions within the flywheel energy storage system

1X.5.4 Electrical power delivery and control systems as well as communications systems, including cabling, wiring, insulation, fans/motors, and cabinetry, should meet the applicable industry design standards for the use intended and duty cycle specified. Such standards should be applied to systems within the flywheel energy storage unit as well as those associated with moving power from the flywheel energy storage units to the grid. As such, this includes power cables and lines, transformers, and power conditioning systems and/or components. Electrical equipment faults are the most likely source of ignition for combustible materials. Electrical equipment should consist of listed arc resistant switchgear.

1X.5.5 Batteries may be employed to provide back-up power in a flywheel energy storage facility and other support structures (e.g., control rooms). Batteries should be provided adequate ventilation and should be kept clean.

1X.5.6 Lightning protection for outdoor installations of flywheel energy storage units, power lines, transformers, and support structures should be provided in accordance with NFPA 780 or IEC 62305, *Protection Against Lightning*.

1X.5.7 Materials of construction should be noncombustible or less-flammable materials whenever possible. Such principles should be applied to flywheel energy storage unit enclosures, O&M/control buildings, and other support structures such as relay houses, switchyard control buildings, and power conditioning buildings.

1X.5.8 Maintenance and inspection of total flooding gaseous agent systems and interlocked equipment are critical.

1X.5.9 For electrical enclosures or cabinetry located in buildings or other such structures, provisions should be addressed for safely removing the gas and potential toxic combustion by-products from these structures following system actuation.

1X.5.9.1 Electrical enclosures, cabinets, and buildings should be arranged for reduced leakage by automatic closing of doors, ventilation dampers, and automatic shutdown of fans.

1X.6 Flywheel Energy Storage System Fire Protection.

1X.6.1 The need for automatic fixed fire protection within a flywheel energy storage unit should be based on the Fire Protection Design Basis Document and associated Fire Risk Evaluation. Fire suppression within sealed electrical enclosures and cabinets is discussed in Chapter 7. A local application system is more appropriate for unsealed electrical enclosures and cabinets within facilities containing the flywheel energy storage systems. Likewise, a local application extinguishing system might be appropriate for the gearbox lubrication system or hydraulic control system. If used, fire suppression capability should be provided for oil piping or any area where oil can flow, accumulate, or spray. Fire extinguishing systems, where provided for hydraulic control equipment, should include protection of reservoirs, pumps, accumulators, piping, and actuating systems. Listed systems should be used.

1X.6.1.2 Discharge rates and duration should be such that cooling and shutdown occur to prevent re-ignition of the fire. System operation should be arranged to coincide with automatic shutdown (i.e. spin down) of the flywheel energy storage unit.

1X.6.1.3 The positioning of local application nozzles should be such that maintenance access to the flywheel energy storage system components is maintained.

1X.6.2 A smoke detection system should be installed in an indoor installation of flywheel energy storage systems to provide early warning and alarm functions in the event of an electrical fire.

1X.6.3 An automatic suppression system should be considered for the enclosures for outdoor installations.

Add to definitions section -

Spin down – A shutdown condition of the flywheel energy storage system, where energy is being dissipated and the flywheel rotor is slowing down to a stop.

Note: A complete stop of the flywheel rotor cannot occur instantaneously because of the high kinetic energy of the rotor, but rather occurs over time due to a gradual slowdown to a stop as a result friction forces acting on the rotor.

Idling – A condition of the flywheel energy storage system where the flywheel is rotating but not providing energy to external loads.

Attachment D: NFPA 850 Public Comment Report

Public Comment No. 42-NFPA 850-2018 [Global Input]

Background and experience with NFPA 850

In our experience we see NFPA 850 as a source of some confusion in contract bidding and negotiations. We see it routinely misunderstood and misapplied in new power generation projects from a variety of potential customers. It is common to have this recommended practice called out as a requirement in a customer specification included with a Request For Proposal. We have had several rounds of follow-up questions regarding compliance with it. In one case a potential customer said their insurance carrier was requiring it in the contract.

NFPA 850 is a “Recommended Practice” which, per sections 3.2.5 and 3.2.6, "contains only nonmandatory provisions" and recommendations "which are advised but not required". Compliance to a "Recommended Practice" document alone with non-mandatory provisions is quite easy - there are no mandatory "shalls" so there is nothing explicitly to comply with. Requiring compliance to NFPA 850 does not make sense in these terms.

Some specification writers are under the impression that requiring compliance means that all the listed recommendations will be applied to their project. We don’t believe that the committee or document intends for all recommendations to be carried out in every plant. It seems impossible to do so. The document is intended to be used as a guide as project stakeholders go through the design basis process themselves and prepare a Design Basis Document (DBD) – through the process in Chapter 4. The document contains numerous good recommendations to support the team as they assess risks and determine the desired specific mitigating design requirements for their specific project. Most of the recommendations have a corresponding cost, and the decision process will weigh the costs and risks for the best solution for the project and customer.

For projects and customers' specifications referencing NFPA 850, you could easily assume that the DBD process has been completed and that the results are integrated into the customer design specifications. By complying with the customer design specs you should also comply with their selected recommendations from NFPA 850. However, in our experience potential customers may not have gone through the Fire Protection Design Process or developed the DBD. So without clarifying during the bidding process you may end up with customer expectations that are not met based on a misunderstanding of the document and process.

Recommendation for the next revision

The driving recommendation that should be considered before all else is the Fire Protection Design Process resulting in a Design Basis Document, detailed in Chapter 4. Please consider revising the format of the document to make it more fool proof in this interpretation. This may include making this a Standard with Chapter 4 only as mandatory and all other content in the nonmandatory appendix, as may have already been raised by some on the committee as a possible change. I think this would help remarkably to clarify the intent and use of the document.

In addition, if the committee would consider it, a short NFPA webinar on the document and process may also help to clarify the use of the document. That would be something you could point a customer or other stakeholder to before or during a negotiation.

Thank you for your consideration.

Statement of Problem and Substantiation for Public Comment

We see NFPA 850 routinely misunderstood and misapplied in new power generation projects from a variety of potential customers. It is common to have this recommended practice called out as a requirement in a customer specification included with a Request For Proposal without a corresponding DBD. This results in confusion during bidding and customer oversight of important system risks during project design.

Related Item

• First Draft Report

Submitter Information Verification

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Public Comment No. 3-NFPA 850-2018 [Section No. 9.6]

~~**9.6** – Turbine-Generator.~~

~~**9.6.1** – Hydrogen System.~~

~~**9.6.1.1 *** – General.~~

~~**9.6.1.1.1** –~~

~~Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable either by "dead man" type controls at the generator fill point(s) or operable from the control room. This would minimize the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant. Alternatively, vented guard piping can be used in the building to protect runs of hydrogen piping.~~

~~**9.6.1.1.2** –~~

~~Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.~~

~~**9.6.1.1.3** –~~

~~Hydrogen cylinders and generator hydrogen fill and purge manifold should be located remote from the turbine generator.~~

~~**9.6.1.1.4** –~~

~~For electrical equipment in the vicinity of the hydrogen handling equipment, see Article 500 of *NFPA 70* and Section 127 of IEEE C2, *National Electrical Safety Code* .~~

~~**9.6.1.2** – Hydrogen Seal Oil Pumps.~~

~~**9.6.1.2.1** –~~

~~Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.~~

~~**9.6.1.2.2** –~~

~~Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire-retardant coating if exposed in the area of the turbine generator to minimize possibility of loss of both pumps as a result of a turbine generator fire.~~

~~**9.6.1.3** –~~

~~Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 6.5 .~~

~~**9.6.1.4** –~~

~~A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply where the generator is opened for maintenance.~~

~~**9.6.1.5** –~~

~~For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of *NFPA 70* and Section 127 of IEEE C2, *National Electrical Safety Code* .~~

~~**9.6.1.6** –~~

~~Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.~~

~~**9.6.1.7** –~~

~~Hydrogen lines should not be piped into the control room.~~

~~**9.6.1.8** –~~

~~The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or an area accessible during a machine fire.~~

~~**9.6.2** – Fire Protection.~~

~~**9.6.2.1** * –~~

~~All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler or foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.30 gpm/ft ^{2} (12.2 mm/min) over a minimum application of 5000 ft ^{2} (464 m ^{2}).~~

~~**9.6.2.2** –~~

~~Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 0.30 gpm/ft ^{2} (12.2 mm/min).~~

~~**9.6.2.3** * –~~

~~Protection for pedestal-mounted turbine generators with no operating floor can be provided by recommendations 9.6.2 and by containing and drainage of oil spills and providing local automatic protection systems for the containment areas. In this type of layout, spray fires from lube oil and hydrogen seal oil conditioning equipment and from control oil systems using mineral oil, if released, could expose building steel or critical generating equipment. Additional protection such as enclosing the hazard, installing a noncombustible barrier between the hazard and critical equipment, or use of a water spray system over the hazard should be considered.~~

~~**9.6.2.4** * –~~

~~Foam-water sprinkler systems installed in place of automatic sprinklers described in Chapter 9 should be designed in accordance with NFPA 16, including the design densities specified in Chapter 9 .~~

~~**9.6.2.5** –~~

~~Electrical equipment in the area covered by a water or foam-water system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.~~

~~**9.6.2.6** * – Turbine-Generator Bearings.~~

~~**9.6.2.6.1** * –~~

~~Turbine-generator bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles or water spray or water mist systems. Automatic actuation is more reliable than manual action. Water spray and sprinkler systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft ^{2} (10.2 mm/min) over the protected area of all bearings.~~

~~**9.6.2.6.2** –~~

~~Where enclosures are provided, compressed air foam systems and hybrid fire-extinguishing systems can be considered.~~

~~**9.6.2.6.3** * –~~

~~Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be permitted to be protected by shields and encasing insulation with metal covers.~~

~~**9.6.2.7** – Exciter.~~

~~The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.~~

~~**9.6.2.8** – Hydrogen Seal Oil.~~

~~Hydrogen seal oil units should be protected in accordance with 9.6.2 .~~

Statement of Problem and Substantiation for Public Comment

The Section 9.6 text is being incorporated to chapter 10 so as to consolidate guidance related to turbines (steam and gas) thereby providing a single location of the information applicable to a combined cycle power plant. This eliminates duplication / cross referencing of information common to both types of machines that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

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Submitter Information Verification

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Public Comment No. 4-NFPA 850-2018 [Section No. 9.8]

9.8 – Lubricating Oil Systems.

9.8.1 * –

Use of a listed fire-resistant (i.e., less hazardous or less flammable) lubricating oil should be considered. The use of a listed fire-resistant fluid as a turbine-generator lubricating oil *(see 7.8.2)* could eliminate the need for fire protection beneath the operating floor and at lubricating oil lines, lubricating oil reservoirs, and turbine-generator bearings to mitigate the hazard posed solely by pool and three-dimensional fires involving lubrication oil. Protection against pool and three-dimensional fires in accordance with 7.13.4.1 should be installed if the hydrogen seal oil system does not use listed fire-resistant fluids. Generator bearings for seal oil systems not using listed fire-resistant fluids should be protected in accordance with 9.6.2.6 . Stakeholders should be involved in the decision-making process before eliminating fire protection for the turbine lubrication oil hazard.

9.8.2 –

Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30.

9.8.3 –

Lubricating oil reservoirs should be provided with a vapor extractor vented to a safe outside location.

9.8.4 –

Curbing or drainage or both should be provided for the turbine lubricating oil reservoir in accordance with Section 6.5 .

9.8.5 –

All oil piping serving the turbine-generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration. *(See NFPA 30 .)*

9.8.6 * –

Piping design and installation should consider the following protective measures:

(1) Welded construction

(2) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time

(3) Route oil piping so as to be clear of, shielded from, or below steam piping, hot metal parts, electrical equipment, or other sources of ignition

(4) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

(5) Noncombustible coverings (e.g., flange guards) around the flange to reduce the possibility of oil spraying onto a hot surface

9.8.7 –

Remote operation from the control room of the condenser vacuum break valve and shutdown of the lubricating oil pumps should be provided. Breaking the condenser vacuum markedly reduces the rundown time for the machine and thus limits oil discharge in the event of a leak. See the discussion in 5.4.6.1 on fire emergency planning involving turbine lubricating oil fires.

9.8.8 –

Cable for operation of lube oil pumps should be protected from fire exposure. Protection can consist of separation of cable for ac and dc oil pumps or 1-hour fire resistive coating (derating of cable should be considered).

9.8.9 – Fire Protection.

~~**9.8.9.1** *~~ –

~~Lubricating oil reservoirs and handling equipment should be protected in accordance with 9.6.2.1 . If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system or a hybrid fire-extinguishing system.~~

Statement of Problem and Substantiation for Public Comment

The Section 9.8 text is being incorporated to chapter 10 so as to consolidate guidance related to turbines (steam and gas) thereby providing a single location of the information applicable to a combined cycle power plant. This eliminates duplication / cross referencing of information common to both types of machines that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 5-NFPA 850-2018 [Section No. 9.9.11]

~~**9.9.11** – Emergency Generators.~~

~~**9.9.11.1** –~~

~~The installation and operation of emergency generators should be in accordance with NFPA 37.~~

~~**9.9.11.2** – Fire Protection.~~

~~**9.9.11.2.1** –~~

~~Emergency generators located within main plant structures should be protected in accordance with NFPA 37.~~

~~**9.9.11.2.2** –~~

~~Where gaseous suppression systems are used on combustion engines that can be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.~~

Statement of Problem and Substantiation for Public Comment

The Section 9.9.11 text is being incorporated to chapter 10 so as to consolidate guidance related to Internal Combustion Engines (ICEs) thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 6-NFPA 850-2018 [Section No. 10.1.1]

10.1.1

Chapter 10 identifies fire and explosion hazards of combustion turbine (CT), steam turbine (ST) and internal combustion engine (ICE) electric generating units and specifies recommended protection criteria.

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 7-NFPA 850-2018 [New Section after 10.1.2]

10.1.3

ST generating facilities consist of turbine assemblies and auxiliary equipment wherein construction consists of incorporating these items into a boiler or HRSG steam system. Although the typical installation is in an open area within a dedicated turbine building, outdoor installations with weather enclosures for the turbine are known and acoustic enclosures may be incorporated for indoor units. As for the CT installations, some recommendations might be more suitable for one type of plant than another.

Statement of Problem and Substantiation for Public Comment

Adding a discussion of Steam Turbines (similar to that for CTs and ICEs) in recognition of the incorporation of ST information in to chapter 10. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 25-NFPA 850-2018 [Section No. 10.1.3]

10.1.~~3~~ 4 *

Modern ICE generating equipment is typically provided as a complete package requiring only a fuel source and electrical connections to the system to be powered. The installations should be either fixed/permanent or installed as a portable/temporary power source. The recommendations of this chapter should be applied to fixed nonresidential installations only.

Statement of Problem and Substantiation for Public Comment

The paragraph number is changed as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 24-NFPA 850-2018 [Section No. 10.1.4]

10.1.4 – 5

Compressors and regulating stations installed on-site should be protected in accordance with the recommendations of Chapter 10.

Statement of Problem and Substantiation for Public Comment

The paragraph number is revised as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 8-NFPA 850-2018 [Section No. 10.2]

10.2 Application of Chapters 4 through ~~10~~ 9 .

The recommendations contained in Chapters 4 through ~~13~~ 9 can apply to turbine and internal combustion ~~turbine~~ engine electric generating units. The Fire Protection Design Basis Document will determine which recommendations apply to any specific CT, ST and ICE electric generating units. This determination is done by evaluating the specific hazards that exist in the facility and evaluating the level of acceptable risk for the facility. For large CT or ST units, or combined cycle plants, it is expected that most of the recommendations will apply, but for individually packaged CT and ICE units, many of the recommendations will not apply since the hazards described might not exist (e.g., small units might not have a cable spreading room or a warehouse).

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Also, corrected the chapter references consistent with other chapters.

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Public Comment No. 9-NFPA 850-2018 [Section No. 10.3]

10.3 ~~Combustion~~ _ Turbine and Internal Combustion Engine Generators.

10.3.1 General.

10.3.1.1

The installation and operation of CT and ICE generators should be in accordance with this chapter and NFPA 37.

10.3.1.2

Site-specific design considerations or manufacturer's typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the CTs or the ICEs. The CT generator is frequently supplied as a complete power plant package with equipment mounted on skids or pads and provided with metal enclosures forming an all-weather housing. In addition to being weathertight, the enclosures are designed to provide thermal and acoustical insulation. Smaller ICE plants might involve enclosures for equipment, but more commonly engine generators are installed in a row in an open room or hall.

10.3.1.3*

The fire and explosion hazards associated with CT and ICE electric generator units are as follows:

(1) Flammable and combustible fuels

(2) Hydraulic and lubricating oils

(3) Electrical and control equipment

(4) Filter media

(5) Combustible enclosure insulation

(6) Internal explosions in CTs

(7) Crankcase explosions in ICEs

10.3.1.4

In the event of a problem with older ICEs, shutdown might be difficult. Several different methods, operating independently, should be provided. These methods can include centrifugally tripped (overspeed condition) spring-operated fuel rack closure, governor fuel rack closure, electropneumatic fuel rack closure, or air inlet guillotine–type air shutoff.

10.3.2 Prevention of Internal Explosions in Combustion Turbines.

10.3.2.1*

Combustion turbines should have a proof-of-flame detection system in the combustion section to detect flameout during operation or ignition failure during startup. In the case of flameout, the fuel should be rapidly shut off. If ignition is not achieved within a normal startup time, then the control system should abort the startup and close the fuel valves.

10.3.2.2

Two safety shutoff valves in series on the main fuel line should be used to minimize the likelihood of fuel leaking into the engine. On gas systems an automatic vent to the outside atmosphere should be provided between the two valves.

10.3.3 Prevention of External Fires.

10.3.3.1

Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as follows:

(1) If rigid metal piping is used, it should be designed with freedom to deflect with the unit, in any direction. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly on the unit. Properly designed metallic hose is an alternative for fuel, hydraulic, and lube oil lines in high vibration areas, between rigid pipe supply lines and manifolds in and at the points of entry at the engine interface.

(2) Rigid piping connected directly to the unit should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the machine. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that can excite its natural frequency.

(3) Welded pipe joints should be used where practical. Threaded couplings and flange bolts in fuel and oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Couplings should have a positive locking device to prevent unscrewing.

(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Liquid level indicators should be listed and protected from impact.

(5) Where practical, lubricating oil lines should use guarded pipe construction with the pressure feed line located inside the return line. If this is not practical, piping sleeves and/or tubing and flange guards should be used to reduce the possibility of oil atomization with subsequent spray fires.

(6) If practical, fluid piping should not be routed above electrical equipment to preclude leaked fluid dripping on the equipment.

10.3.3.2*

In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistant fluid should be considered. If separate systems are used, the hydraulic control system should use a listed fire-resistive hydraulic fluid, and a listed fire-resistant fluid should be considered for the lubricating system.

10.3.3.3

Combustible gas detector(s) should be considered for the CT and ICE enclosures.

10.3.3.4

For recommendations regarding containment and drainage of liquids, see Section 6.5.

10.3.3.5

In order to prevent conditions that could cause a fire while the unit is operating, control packages should include the parameter monitoring and shutdown capabilities described in Chapter 9 of NFPA 37.

10.3.4 Fire Protection for Combustion Turbines and Internal Combustion Electrical Generators.

10.3.4.1

Determination of the need for fire suppression for the combustion turbine engine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage.

10.3.4.1.1

Fire system operation should be arranged to close the fuel valves except for ICE emergency power supply systems (e.g., hospital emergency power).

10.3.5 Inlet Air System.

10.3.5.1*

Air filters and evaporative cooling media should be constructed from less flammable materials whenever practical. ANSI/UL 900, *Standard for Safety Test Performance of Air Filters,* can be used as guidance.

10.3.5.2

Manual fire-fighting equipment should be available to personnel performing maintenance on air filters.

10.3.5.3

Access doors or hatches should be provided for manual fire fighting on large air filter structures.

10.3.6 Generators.

10.3.6.1

Hydrogen systems should comply with recommendations in 9.6.1 and 9.6.2.8.

10.3.6.2

Fire protection should be provided in accordance with 10.3.4 for generator bearings and oil piping or any area where oil can flow, accumulate, or spray.

10.3.6.3*

Air-cooled generators should be tightly sealed against the ingress of moisture in the event of discharge (accidental or otherwise) of a water spray system. Sealing should be positive, such as by a gasket or grouting, all around the generator housing.

10.3.7 Starting Equipment for CTs.

Where ICEs or torque converters are used, fire protection should be provided based on consideration of the factors in 10.3.4.1.

Statement of Problem and Substantiation for Public Comment

Modifying the title to reflect the incorporation of Steam Turbine information in to chapter 10. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 10-NFPA 850-2018 [Section No. 10.3.1.2]

10.3.1.2

Site-specific design considerations or manufacturer's typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the CTs, STs or ~~the~~ ICEs. The CT generator is frequently supplied as a complete power plant package with equipment mounted on skids or pads and provided with metal enclosures forming an all-weather housing. In addition to being weathertight, the enclosures are designed to provide thermal and acoustical insulation. ST generators are typically supplied as components that are incorporated into the power plant design and installed in an open room or separate building. Metal acoustic enclosures are available as options for some ST generators. Smaller ICE plants might involve enclosures for equipment, but more commonly engine generators are installed in a row in an open room or hall.

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 11-NFPA 850-2018 [Section No. 10.3.1.3]

10.3.1.3*

The fire and explosion hazards associated with CT, ST and ICE electric generator units are as follows:

(1) Flammable and combustible fuels

(2) Hydraulic and lubricating oils

(3) Electrical and control equipment

(4) Filter media

(5) Combustible enclosure insulation

(6) Internal explosions in CTs

(7) Crankcase explosions in ICEs

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 12-NFPA 850-2018 [Section No. 10.3.1.4]

10.3.~~1~~ 4 .4

In the event of a problem with older ICEs, shutdown might be difficult. Several different methods, operating independently, should be provided. These methods can include centrifugally tripped (overspeed condition) spring-operated fuel rack closure, governor fuel rack closure, electropneumatic fuel rack closure, or air inlet guillotine–type air shutoff.

Statement of Problem and Substantiation for Public Comment

Modifying the location of the text to consolidate with other ICE guidance andto fit with the incorporation of Steam Turbine information in to chapter 10. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 13-NFPA 850-2018 [Section No. 10.3.2]

10.3.2– .3 _ Prevention of Internal Explosions in Combustion Turbines.

10.3.2.3. 1*

Combustion turbines should have a proof-of-flame detection system in the combustion section to detect flameout during operation or ignition failure during startup. In the case of flameout, the fuel should be rapidly shut off. If ignition is not achieved within a normal startup time, then the control system should abort the startup and close the fuel valves.

10.3.2.3. 2

Two safety shutoff valves in series on the main fuel line should be used to minimize the likelihood of fuel leaking into the engine. On gas systems an automatic vent to the outside atmosphere should be provided between the two valves.

Statement of Problem and Substantiation for Public Comment

Modifying the location of the text to provide a better flow considering the incorporation of moved information from chapter 9 into the section renumbered as 10.3.1.4. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 15-NFPA 850-2018 [Section No. 10.3.3]

10.3.3 – 1.4 _ Prevention of External Fires.

10.3.3 1 .4. 1

Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as follows:

(1) If rigid metal piping is used, it should be designed with freedom to deflect with the unit, in any direction. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly on the unit. Properly designed metallic hose is an alternative for fuel, hydraulic, and lube oil lines in high vibration areas, between rigid pipe supply lines and manifolds in and at the points of entry at the engine interface.

(2) Rigid piping connected directly to the unit should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the machine. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that can excite its natural frequency.

(3) Welded pipe joints should be used where practical. Threaded couplings and flange bolts in fuel and oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Couplings should have a positive locking device to prevent unscrewing.

(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Liquid level indicators should be listed and protected from impact.

(5) Where practical, lubricating oil lines should use guarded pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time _ . If this is not practical, noncombustible coverings (e.g., _ piping sleeves and/or tubing and flange guards) should be used to reduce the possibility of oil atomization and contact with hot surfaces _ with subsequent spray fires.

(6) If practical, fluid piping should ~~not~~ be ~~routed above electrical equipment~~ clear of, shielded from or routed _ below steam piping, hot metal parts, _ electrical equipment _ or other sources of ignition _ to preclude leaked fluid dripping on the equipment.

(7) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

10.3. 1.4.2*

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler or foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.30 gpm/ft2 (12.2 mm/min) over a minimum application of 5000 ft2 (464 m2).

10. 3. 1.4.3

Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 0.30 gpm/ft2 (12. 2 mm/min).

10.3.1.4.4 *

Protection for pedestal-mounted turbine generators with no operating floor can be provided by recommendations 10.3.1.4 and by containing and drainage of oil spills and providing local automatic protection systems for the containment areas. In this type of layout, spray fires from lube oil and hydrogen seal oil conditioning equipment and from control oil systems using mineral oil, if released, could expose building steel or critical generating equipment. Additional protection such as enclosing the hazard, installing a noncombustible barrier between the hazard and critical equipment, or use of a water spray system over the hazard should be considered.

10.3.1.4.5

Foam-water sprinkler systems installed in place of automatic sprinklers should be designed in accordance with NFPA 16, including the design densities specified in Chapter 9

10.3.1.4.6

Electrical equipment in the area covered by a water or foam-water system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

10.3.1.4.7 *

In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistant fluid should be considered. If separate systems are used, the hydraulic control system should use a listed fire-resistive hydraulic fluid, and a listed fire-resistant fluid should be considered for the lubricating system.

~~10.3.3.4~~ –

10.3.3.3 –

~~Combustible gas detector(s) should be considered for the CT and ICE enclosures.~~

1.4.8

For recommendations regarding containment and drainage of liquids, see Section 6.5.

10.3.3.5 – 1.4.9

In order to prevent conditions that could cause a fire while the unit is operating, control packages should include the parameter monitoring and shutdown capabilities described in Chapter 9 of NFPA 37.

10.3.1.5 Lubricating Oil Systems.

10.3.1.5.1

Use of a listed fire resistant (i.e., less hazardous or less flammable) lubricating oil should be considered. The use of a listed fire-resistant fluid as a turbine-generator lubricating oil (see 7.8.2) could eliminate the need for fire protection beneath the operating floor, at lubricating oil lines, lubricating oil reservoir, and turbine-generator bearings to mitigate the hazard posed solely by pool and three-dimensional fires involving lubrication oil. Protection against pool and three-dimensional fires in accordance with 7.13.4.1 should be installed if the hydrogen seal oil system does not use listed fire-resistant fluids. Generator bearings for seal oil systems not using listed fire-resistant fluids should be protected in accordance with 10.3.3.1. Stakeholders should be involved in the decision making process before eliminating fire protection for the turbine lubrication oil hazard.

10.3.1.5.2

Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30.

10.3.1.5.3

Lubricating oil reservoirs should be provided with and ICE added to a vapor extractor, vented to a safe outside location.

10.3.1.5.4

Curbing or drainage or both should be provided for the lubricating oil reservoir in accordance with Section 6.5.

10.3.1.5.5

All oil piping serving the turbine, ICE or generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration. (*See NFPA 30* .)

10.3.1.5.6

Remote operation from the control room of the condenser vacuum break valve and shutdown of the lubricating oil pumps should be provided. Breaking the condenser vacuum markedly reduces the rundown time for the machine and thus limits oil discharge in the event of a leak. See the discussion in 5.4.6.1 on fire emergency planning involving turbine lubricating oil fires.

10.3.1.5.7

Cable for operation of lube oil pumps should be protected from fire exposure. Protection can consist of separation of cable for ac and dc oil pumps or 1-hour fire resistive coating (derating of cable should be considered).

10.3.1.5.8 Fire Protection.

10.3.1.5.8 .1

Lubricating oil reservoirs and handling equipment should be protected in accordance with 10.3.1.4.2 **.** If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system or a hybrid fire extinguishing system.

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Specific sections of Chapter 9 incorporated into this section include:

- 9.8.6 (incorporated into existing text now numbered as 10.3.1.4.1)
- 9.6.2.1 (as 10.3.1.4.2)
- 9.6.2.2 (as 10.3.1.4.3)
- 9.6.2.3 (as 10.3.1.4.4)
- 9.6.2.4 (as 10.3.1.4.5)
- 9.6.2.5 (as 10.3.1.4.6)
- 9.8 except for 9.8.6 as stated above (as 10.3.1.5) and ICE added to 10.3.1.5.5 as that is also applicable

Related Item

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Public Comment No. 18-NFPA 850-2018 [Section No. 10.3.3.3]

10.3. 2 Combustion Turbines

10. 3.

~~3~~

2.1

Combustible gas detector(s) should be considered for the CT ~~and ICE~~ enclosures.

Statement of Problem and Substantiation for Public Comment

Modifying the location of the text to provide a better flow considering the incorporation of information from chapter 9. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 19-NFPA 850-2018 [Section No. 10.3.4]

10.3.4 – 2.2 Fire Protection ~~for Combustion Turbines and Internal Combustion Electrical Generators.~~

10.3.4 2 .2. 1

Determination of the need for fire suppression for ~~the~~ combustion ~~turbine engine~~ turbines should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance.

10.3.4 2 .2. 1.1 –

Fire system operation should be arranged to close the fuel valves ~~except for ICE emergency power supply systems (e .g., hospital emergency power).~~

Statement of Problem and Substantiation for Public Comment

Modifying the location and text to reflect the incorporation of Steam Turbine information in to chapter 10 and collect CT specific information in a single location. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 16-NFPA 850-2018 [Section No. 10.3.5]

10.3.5 – 1.6 Inlet Air System.

10.3.5 1 .6. 1*

Air filters and evaporative cooling media should be constructed from less flammable materials whenever practical. ANSI/UL 900, *Standard for Safety Test Performance of Air Filters,* can be used as guidance.

10.3.5 1 .6. 2

Manual fire-fighting equipment should be available to personnel performing maintenance on air filters.

10.3.5 1 .6. 3

Access doors or hatches should be provided for manual fire fighting on large air filter structures.

Statement of Problem and Substantiation for Public Comment

Modifying the location of the text to provide a better flow considering the incorporation of information from chapter 9. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

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Public Comment No. 22-NFPA 850-2018 [Section No. 10.3.6]

10.3.6 – 5 _ Generators.

10.3.

~~6~~

5 .1

_

~~Hydrogen systems should comply with recommendations in 9.6.1 and 9.6.2.8 .~~

~~**10.3.6.2**~~ –

~~Fire protection should be provided in accordance with 10.3.4 for generator bearings and~~

Hydrogen Cooled Generators

10.3.5.1.1*

Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable either by "dead man" type controls at the generator fill point(s) or operable from the control room. This would minimize the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant. Alternatively, vented guard piping can be used in the building to protect runs of hydrogen piping.

10.3.5.1.2

Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.

10.3.5.1.3

Hydrogen cylinders and generator hydrogen fill and purge manifold should be located remote from the turbine generator.

10.3.5.1.4

For electrical equipment in the vicinity of the hydrogen handling equipment, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code* .

10.3.5.2 Hydrogen Seal Oil System

10.3.5.2.1

Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

10.3.5.2.2

Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire-retardant coating if exposed in the area of the turbine generator to minimize possibility of loss of both pumps as a result of a turbine generator fire.

10.3.5.2.3

Hydrogen seal oil units should be protected in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.1.4.2 through 10.3.1.4.6.

10.3.5.3

Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 6.5.

10.3.5.4

A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply where the generator is opened for maintenance.

10.3.5.5

For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of NFPA 70 and Section 127 of IEEE C2, *National Electrical Safety Code* .

10.3.5.6

Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.

10.3.5.7

Hydrogen lines should not be piped into the control room.

10.3.5.7

The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or an area accessible during a machine fire.

10.3.5.9

Fire protection should be provided in accordance with an appropriate method selected from Section 7.6 and considering the guidance provided in 10.3.3.1 for turbine bearings and 10.3.1.4.2 through 10.3.1.4.5 for oil piping or any area where oil can flow, accumulate, or spray.

10.3.

~~6.3~~

5.9 .1

Exciter. The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

10.3.3.5.10 *

Air-cooled generators should be tightly sealed against the ingress of moisture in the event of discharge (accidental or otherwise) of a water spray system. Sealing should be positive, such as by a gasket or grouting, all around the generator housing.

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine - Generator information in to chapter 10 so as to consolidate guidance related to gas and steam turbine generators thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Specific sections of Chapter 9 incorporated into this section include:

- 9.6.1 (as 10.3.5.1)
- 9.6.1.1.1/2/3/4 (as 10.3.5.1.1/2/3/4)
- 9.6.1.2 (as 10.3.5.2)
- 9.6.2.8 (as 10.3.5.2.3)
- 9.6.1.3 (as 10.3.5.3)
- 9.6.1.4 (as 10.3.5.4)
- 9.6.1.5 (as 10.3.5.5)
- 9.6.1.6 (as 10.3.5.6)
- 9.6.1.7 (as 10.3.5.7)
- 9.6.1.8 (as 10.3.5.8)
- 9.6.2.7 (as 10.3.5.9.1)

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Public Comment No. 23-NFPA 850-2018 [New Section after 10.3.6.3]

10.3.6 Emergency Generators.

10.3.6.1

The installation and operation of emergency generators should be in accordance with NFPA 37.

10.3.6.2 Fire Protection.

10.3.6.2.1

Emergency generators located within main plant structures should be protected in accordance with NFPA 37.

10.3.6.2.2

Where gaseous suppression systems are used on combustion engines that can be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.

Statement of Problem and Substantiation for Public Comment

Moving the text from Chapter 9 where it was somewhat unrelated to the section to Chapter 10 section on generators thereby consolidating generator information. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

• First Revision No. 12-NFPA 850-2018 [Global Input]

Submitter Information Verification

Submitter Full Name: Larry Danner
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Submittal Date: Wed Nov 07 13:13:23 EST 2018
Committee: ECG-AAA

Public Comment No. 17-NFPA 850-2018 [Section No. 10.3.7]

10.3.1. 7 Starting Equipment for CTs.

Where ICEs or torque converters are used, fire protection should be provided based on consideration of the factors in 10.3.4.1.

Statement of Problem and Substantiation for Public Comment

Modifying the location of the text to provide a better flow considering the incorporation of information from chapter 9. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

• First Revision No. 12-NFPA 850-2018 [Global Input]

Submitter Information Verification

Submitter Full Name:	Larry Danner
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Committee:	ECG-AAA

Public Comment No. 21-NFPA 850-2018 [New Section after 10.4.2]

10.3.4 Internal Combustion Engines.

10.3.4.1

Combustible gas detector(s) should be considered for the ICE enclosures.

10.3.4.2

Determination of the need for fire suppression for the internal combustion engine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage. See Chapter 7 for general fire protection methods guidance.

10.3.4.3

Fire system operation should be arranged to close the fuel valves except for ICE emergency power supply systems (e.g., hospital emergency power).

Statement of Problem and Substantiation for Public Comment

Creating the ICE Specific guidance by separating it from the combustion turbine information and combining with other ICE specific and unique information in the chapter to provide the consolidated information in a single location. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

- First Revision No. 12-NFPA 850-2018 [Global Input]

Submitter Information Verification

Submitter Full Name: Larry Danner
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Street Address:
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Committee: ECG-AAA

Public Comment No. 20-NFPA 850-2018 [Section No. 10.4.2]

10.4 3 ~~.2~~ – 3 Steam Turbines.

Steam turbines, ~~generators,~~ and their associated hazards should be designed and protected in accordance with ~~Section 9~~ an appropriate method selected from Section 7 .6 and considering the guidance provided in 10 . 3.1.4.2 through 10.3.1.4.8.

10.3.3.1 **Bearings**

10.3.3.1.1

Turbine bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles or water spray or water mist systems. Automatic actuation is more reliable than manual action. Water spray and sprinkler systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft2 (10.2 mm/min) over the protected area of all bearings.

10.3.3.1.2

Where enclosures are provided, compressed air foam systems and hybrid fire-extinguishing systems can be considered.

10.3.3.1.3

Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be permitted to be protected by shields and encasing insulation with metal covers.

Statement of Problem and Substantiation for Public Comment

Modifying the text to reflect the incorporation of Steam Turbine information in to chapter 10 so as to consolidate guidance related to gas and steam turbines thereby providing a single location of the information applicable to this class of equipment. This eliminates duplication / cross referencing of information that was previously located in two separate chapters. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Specific sections of Chapter 9 incorporated into this section include:

- 9.6.2.6 (as 10.3.3.1)

Related Item

- First Revision No. 12-NFPA 850-2018 [Global Input]

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Submitter Full Name: Larry Danner
Organization: Ge Power & Water
Street Address:
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Public Comment No. 2-NFPA 850-2018 [Section No. A.6.1.4.2(9)]

A.6.1.4.2(9)

Oil-filled transformer explosions and fires can be prevented in some cases by the installation of a passive mechanical system designed to depressurize the transformer a few milliseconds after the occurrence of an electrical fault. An example is provided in D.2.14. This fast depressurization can be achieved by a quick oil evacuation triggered by the ~~dynamic~~ transient pressure peak generated by the short circuit. The protection technology activates within milliseconds before static pressure increases, therefore preventing transformer explosion and subsequent fire. However, because these devices do not eliminate a fire potential resulting from all forms of transformer failure (e.g., transformer bushing failure), they should be considered as a possible supplement to passive protection features such as physical barriers or spatial separation, not as an alternative to these features. The systems can include outflow devices that are located directly on the high-risk areas of the bushing turrets and oil-bushing cable boxes.

Statement of Problem and Substantiation for Public Comment

Dynamic pressure is a vague terminology. Replacing it with the term "transient" would help the reader understand and interpret the standard better.

Related Item

-

Submitter Information Verification

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Street Address:
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Submittal Date: Thu Nov 01 15:50:32 EDT 2018
Committee: ECG-AAA

Public Comment No. 1-NFPA 850-2018 [Section No. A.9.5.2.6]

A.9.5.2.6

All signs of spontaneous combustion and fire must be eliminated prior to the movement of coal.

Manual Fire Suppression. Fire fighting in coal silos is a long and difficult activity. Some firefighting operations have taken several days to completely extinguish a fire.

~~Smoldering~~ >Smoldering coal in a coal bin, bunker, or silo is a potentially dangerous situation that depends on the location of the smoldering coal. There is a risk of a flash fire or explosion if the smoldering coal is disturbed. This risk should be considered in preplanning. Personnel responding to a coal fire should have proper personal protective equipment, including SCBA and turnout gear, and training in this hazard.

The area surrounding the smoldering coal should also be considered. The potential of developing an immediately dangerous to life and health (IDLH) atmosphere is possible. This should also be considered in preplanning.<

General: My input regards a safety issue.

Electrostatic discharges are generated when liquid CO_2 is released. It's a known source of ignition, e.g. in NFPA 77.

This is not problem for fighting a fire with flames. But a hot spot may have filled the headspace with flammable pyrolysis gases. If ignited due to CO_2 injection, a confined explosion will result.

Problem: NFPA 850 does not mention this hazard.

For further info, please refer to this article on an explosion caused by injection of CO_2 Hedlund (2018) Carbon dioxide not suitable for extinguishment of smouldering silo fires: static electricity may cause silo explosion. Biomass and Bioenergy. 108:113-119. https://doi.org/10.1016/j.biombioe.2017.11.009

This is merely a friendly service message. I'm not a US citizen and have no means to enter a lengthy comments procedure for a US standard. Unfortunately, I cannot take this issue further with NFPA.

Depending on the strategy selected, resource demands will be varied but challenging. Prefire planning is an important element in successful silo fire control and should be included in the Fire Protection Design Basis Document*(see Chapter 4)* and the fire emergency plan *(see 5.4.4)*. Control room operators should be involved with the preplanning.

Use of Water Additives. Use of water additives has been successful in recent years, especially for sub-bituminous coal fires. Application of water additives is the preferred fire suppression method of the PRB Coal Users' Group for bunker, hopper, and silo fire protection *(see the PRB Coal Users' Group Recommended Practice, Coal Bunker, Hopper & Silo Fire Protection Guidelines).*

Baseline guides and procedures for preplanning and applying water additives to these fires are included in the PRB Coal Users' Group document. These guides and procedures can be used as a starting point by the owner's structural fire brigade and local fire department to customize the approach for the specific facility. These fire-fighting activities are inherently dangerous and should not be performed by incipient fire brigades or other personnel. The document is available to members of the PRB Coal Users' Group online at www.prbcoals.com.

The application of water additives can be enhanced by using an infrared camera to search for hot spots, either on the sides or top of the silo, to facilitate injection as close as possible to the fire area. The infrared imagery can be used to evaluate performance and monitor progress of the attack. The solution must penetrate to the seat of combustion to be effective. This penetration can be affected by the degree of compaction, voids, rate of application, evaporation rate, and so forth. Runoff must be drained through feeder pipe and will require collection, cleanup, and disposal.

Use of Class A Foams and Penetrants. Use of Class A foams and penetrants has had some success, but it has been difficult to predict the resources required for successful fire control. The agents generally require mixing with water prior to application, usually in the range of 1 percent by volume, mixed in a manner similar to Class B agents. While the typical application of Class A foam is to fight wildland fires at 1 percent, many plants have reported success with using Class A foams at 0.1 percent. This causes the agent to act as a surfactant. Higher proportions have caused excessive bubble accumulation that impedes penetration into the coal.

The application of foams and penetrants can be enhanced by using an infrared camera to search for hot spots, either on the sides or top of the silo, to facilitate injection of the agent as close as possible to the fire area. The infrared imagery can be used to evaluate performance and monitor progress of the attack. The water/agent solution must penetrate to the seat of combustion to be effective. This penetration can be affected by the degree of compaction, voids, rate of application, evaporation rate, and so forth. Runoff must be drained through feeder pipe and will require collection, cleanup, and disposal.

Use of Inerting Gas. Carbon dioxide and nitrogen have been used successfully as gaseous inerting systems. Carbon dioxide vapor, with a density of 1.5 times that of air, has proven to be effective in quickly establishing an inert atmosphere in the space above the coal, which prevents the creation of an explosive atmosphere in that space.

At the same time the CO_2 vapor can be injected into the stored coal from the lower part of the silo, where fires are most likely to originate. This CO_2 inerts the voids between the coal pieces while filling the silo from the bottom up with CO_2 vapor. The CO_2 vapor injection rate is that needed to exceed any losses at the bottom of the silo while pushing the inert gas up through the coal at a reasonable rate. (Very tall silos require intermediate injection points for the CO_2 vapor between the top and bottom of the silo.)

~~Since~~ >Since carbon dioxide is stored as a compressed liquified gas, it must be vaporized before injection into the silo. External vaporizers are used and sized to handle the maximum anticipated CO_2 vapor flow rates.<

My comment: It is not clearly stated, that vaporization is required to avoid electrostatic discharges, not just because CO2 is a "liquefied gas"

It is common practice to monitor the carbon monoxide (CO) level while inerting with CO_2. If the CO level does not decrease, the controls on the CO_2 system are designed to allow for increasing the inerting rate. The flow can also be reduced to conserve the CO_2 supply once fire control has been established.

A large imbedded coal fire provides a heated mass that will be extremely difficult to extinguish with CO_2 alone. It is, however, important that supplemental fire fighting be done in an inert environment. The CO_2 system's primary mission is to prevent the large fire from occurring by detecting the fire early by the CO detectors while it is still small and then inerting to contain and extinguish.

~~Bulk~~ >Bulk liquid CO_2 units are generally used, but cylinders can be used for inerting smaller silos. (The bulk CO_2 supply is frequently used for other applications such as pulverizer inerting, generator hydrogen purge, and some fire suppression system applications in the turbine building.) The bulk CO_2 units have the capability of being refilled while they are being used. For the smaller silos, CO_2 vapor is withdrawn from manifolded cylinders without siphon tubes.<

My comment: That CO2 can be safely drawn from a CO2 cylinder " without siphon tubes" appears to be a highly problematic statement. I suggest to at least notify the reader of the hazard of electrostatic discharge generation.

Carbon dioxide inerting has a beneficial effect as soon as it reaches the oxidizing coal. As the supporting oxygen level drops, less heat is generated, helping to limit fire spread. But to totally extinguish any large burning coal mass can require a very high CO_2 concentration held for a long time since the cooling capacity of the CO_2 is relatively small and the coal itself tends to retain heat.

The CO_2 system should be considered as a fire prevention/fire containment system. The system can be operated from a dedicated manual release station or by the plant programmable logic controller (PLC) from the control room. Plant personnel need not be involved except to adjust the CO_2 flow rates as needed to manage the inerting or fire suppression.

When carbon dioxide is used, there is a risk of oxygen depletion in the area above, around, or below a silo, bin, or bunker. Areas where gas could collect and deplete oxygen, which might include the tripper room and areas below the discharge feeder gate, should be identified with appropriate barriers and warning signs.

Nitrogen has been used successfully to inert silo fires. It is applied in a manner very similar to carbon dioxide. A notable difference is that nitrogen has about the same density as air (whereas carbon dioxide is significantly more dense). Therefore, it must be applied at numerous injection points around the silo to ensure that it displaces available oxygen, which results in the need for more injection equipment and a larger quantity of agent.

Emptying the Silo. The silo can be unloaded through the feeder pipe, but it is a dirty, messy operation. It is necessary to bypass the feeder belt and to dump the coal onto the floor of the power house at the feeder elevation. A hose crew should be available to extinguish burning coal as it is discharged from the silo. There is a risk that dust raised during this activity can ignite explosively. High-expansion foam can be applied.

Carbon monoxide produced during the combustion process will also tend to settle in the lower elevation and can be a hazard to the hose crew. Once spilled and extinguished, it is usually necessary to shovel the coal into a dump truck for transport back to the coal pile.

Manual Fire-Fighting. Regardless of the type of suppression approach selected, prefire planning is an important element of successful fire control and extinguishment. All necessary resources should be identified and in place prior to beginning fire suppression activities. If necessary materials are not stockpiled on-site, suppliers should be contacted in advance to ensure that equipment and supplies are available on relatively short notice.

The personnel requirements for this fire-fighting activity should be identified in advance. Personnel should be trained and qualified for fire-fighting in the hot, smoky environment that might accompany a silo fire. This training includes the use of self-contained breathing apparatus and personal protective equipment. Personnel engaged in this activity should be minimally trained and equipped to the structural fire brigade level as defined in NFPA 600. If station personnel are not trained in use of self-contained breathing apparatus, it will be necessary for the public fire department to perform fire-fighting in these areas. Station personnel are still needed to assist with operational advice and guidance. The public fire-fighting agency that responds to a fire at the facility should be involved in preplanning fire-fighting activities for silo fires. The public fire service might need specific instruction concerning operation and potential hazards associated with coal silo fires as well as operation in the power plant environment. It is important that the responding fire service be supplied information and guidance at every opportunity.

The resources of the station and the local fire service need to work in concert, including working with control room operators and keeping them apprised of fire control operations. Preplanning should include administrative details such as chain of command, access, and so forth. Operations should be coordinated by an established incident command system in conformance with NFPA 1561. All personnel should be familiar with and practice this system prior to the event.

Statement of Problem and Substantiation for Public Comment

NFPA 850 - silent on electrostatic hazard of CO_2 injection, potentially leading to explosion
Comment to Annex A, section A.9.5.2.6

General: My input concerns a safety issue.
Electrostatic discharges are generated when liquid CO_2 is released. It's a known source of ignition, e.g. in NFPA 77.
This is not problem for fighting a fire with flames. But a hot spot may have filled the headspace with flammable pyrolysis gases. If ignited due to CO_2 injection, a confined explosion will result.
Problem: NFPA 850 does not mention this hazard.
For further info, please refer to this article on an explosion caused by injection of CO_2 Hedlund (2018) Carbon dioxide not suitable for extinguishment of smouldering silo fires: static electricity may cause silo explosion. Biomass and Bioenergy. 108:113-119. https://doi.org/10.1016/j.biombioe.2017.11.009
This is merely a friendly service message. I'm not a US citizen and have no means to enter a lengthy comments procedure for a US standard. Unfortunately, I cannot take this issue further with NFPA.
regards,
Frank H Hedlund, Denmark

Related Item

• First draft report, Annex A

Submitter Information Verification

Submitter Full Name: Frank Hedlund
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Submittal Date: Sat Sep 29 16:19:22 EDT 2018
Committee: ECG-AAA

Public Comment No. 39-NFPA 850-2018 [Section No. A.9.6.1.1]

A.9 10 .6 3 .5. 1.1

For hydrogen storage systems, see NFPA 2.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Submitter Full Name: Larry Danner

Organization: Ge Power & Water

Street Address:

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Submittal Date: Wed Nov 07 14:37:17 EST 2018

Committee: ECG-AAA

Public Comment No. 28-NFPA 850-2018 [Section No. A.9.6.2.1]

A.~~9~~ 10 .~~6~~ 3 .~~2.1~~ 1.4.2

To avoid water application to hot parts or other water sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element operated directional spray nozzles can be necessary.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

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Submitter Full Name: Larry Danner

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Public Comment No. 29-NFPA 850-2018 [Section No. A.9.6.2.3]

A.~~9~~ 10 .~~6~~ 3 .~~2.3~~ 1.4.4

Above the operating floor, ceiling level sprinkler systems might not be effective to protect floor level equipment and components from oil fires because of the high ceilings [typically in excess of 40 ft (12 m)].

A spray fire can blow past conventional automatic sprinkler protection without operating the system and can expose structural steel or critical components of the turbine generator. The concern is that fire exposure to the roof for the rundown time of the turbine could bring down building steel and result in damage to long lead time equipment critical to operation of the turbine or that the fire could directly expose critical equipment such as the generator. Where possible, one of the following protection measures should be used:

(1) *Enclosure of the hazard.* An example would be location within a room of noncombustible construction protected with automatic sprinkler protection.

(2) *Use of a barrier.* A metal barrier could be installed between the hazard and critical equipment or the roof of the building with automatic sprinklers installed under the barrier.

(3) *Water spray protection.* Tests have shown that deluge sprinklers over the hazard can reduce the size of an oil spray fire. The tests were conducted with pendant sprinklers spaced 5 ft × 5 ft (1.5 m × 1.5 m) apart, with an orifice coefficient of K-8.0 (115) and an end head pressure of 50 psi (3.9 bar) located 6 ft (1.8 m) over the hazard. The system should be automatically activated by a listed line type heat detection or flame detection system.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 30-NFPA 850-2018 [Section No. A.9.6.2.4]

A.~~9~~ 10 .~~6~~ 3 .~~2~~ 1 .~~4~~ .5

Protein and aqueous film-forming foams (AFFF) are effective in control of flammable liquid pool fires in high bay buildings. FM Global conducted tests for the Air Force at the Test Campus in 1975. Flammable liquid pool fires 900 ft^2 (83.6 m^2) in area were used. Foam was applied from nozzles at ceiling level 60 ft (18.3 m) above the floor. Foam reduced the fire area by 90 percent less than 5 minutes after application started. It is effective on high flashpoint liquid fires such as mineral oil. Tests have also been conducted using foam for the protection of chemical process structures. The tests involved a three-dimensional spill of flammable liquid from a process vessel 20 ft (6.1 m) above the floor onto grade level. The process structure was 40 ft (12.2 m) high. Foam protection was provided at each floor elevation. Foam limited the size of the pool fire but had no effect on the three-dimensional spill fire.

Micelle-encapsulating agents can enhance open head water spray systems for pool fires. Research has been conducted for use of this agent on some hydrocarbon pool fires, although turbine lubricating oil has not been tested. In addition, testing has not been performed for three-dimensional fire scenarios that can occur during a turbine lubricating oil spray fire. See A.9.5.2.6 for additional information on micelle-encapsulating agents.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Submitter Information Verification

Submitter Full Name: Larry Danner
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Street Address:
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Submittal Date: Wed Nov 07 14:09:26 EST 2018
Committee: ECG-AAA

Public Comment No. 35-NFPA 850-2018 [Section No. A.9.6.2.6]

A.~~9~~ 10 .~~6~~ 3 .~~2~~ 1 .~~6~~ — 1

Additional information concerning turbine-generator fire protection can be found in EPRI Research Project 1843-2 report, *Turbine Generator Fire Protection by Sprinkler System*.

In February 1997 the National Institute of Standards and Technology published NIST Report Technical Note 1423, "Analysis of High Bay Hanger Facilities for Fire Detector Sensitivity and Placement." This report provides design recommendations for sprinkler and detection systems (protecting fuel pool fires) at those facilities, which can provide some design guidance if sprinkler systems are installed at the ceiling level of the turbine building.

However, turbine building hazards include pool fires and three-dimensional and spray fires. Without further testing, such systems should not be considered to provide equivalent protection to the turbine building systems recommended in the body of NFPA 850. If used in addition to those recommended systems, a properly designed ceiling level sprinkler system can provide additional protection for the turbine building roof if exposure to a large fire on the operating floor is a concern.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

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Submitter Full Name: Larry Danner

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Committee: ECG-AAA

Public Comment No. 36-NFPA 850-2018 [Section No. A.9.6.2.6.1]

A.~~9~~ 10 .~~6~~ 3 .~~2~~ 3 .~~6~~ 1 .1

Automatically actuated systems have proven to actuate properly under fire conditions and are not prone to spurious actuation. If a manually operated water system is installed, consideration should be given to a supplemental automatic gaseous fire extinguishing system.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Submitter Full Name:	Larry Danner
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Committee:	ECG-AAA

Public Comment No. 37-NFPA 850-2018 [Section No. A.9.6.2.6.3]

A.~~9~~ 10 .~~6~~ 3 .~~2~~ 3 .~~6~~ 1 .3~~ ~~

The 2000 edition of NFPA 850 allowed manual operation of bearing protection systems. In most incidents involving bearing oil releases this would be adequate. In some types of release, such as seal oil failures, that might not allow the operator time to activate the system. There are some turbine buildings where the control room is not located in the turbine building, which would also delay response.

If turbine-generator bearings are protected with a manually operated sprinkler system, the following should be provided:

(1) Manual activation should be from the control room or a readily accessible location not exposing the operator to the fire condition. Staffing of plant should be sufficient to promptly handle this function as well as other responsibilities during an emergency of this nature.

(2) Automatic fire detection should be provided over the area of each bearing and within the skirting of the turbine where a potential for oil to pool can alert operators to a fire condition.

(3) Documented procedures should be in place with authorized approval given to operators to activate the system if necessary in a fire condition.

(4) Periodic training should be given to operators regarding the need for prompt operation of the system.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

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Public Comment No. 32-NFPA 850-2018 [Section No. A.9.8.1]

A.9 10 .8 3 .1— .5.1

There is limited information available detailing industry experience with fire-resistant fluids as turbine lubrication oils or in seal oil systems. The use of fire-resistant fluids in hydraulic systems is common in the utility industry. Literature is available documenting use of these fluids in Europe. Information detailing operational experience using fire-resistant fluids on lubrication oil systems on turbine-generators in North America is limited.

Utilizing a listed fire-resistant turbine lubricating oil potentially reduces the hazard associated with the lubricating oil system, but the remaining hazards still need to be addressed in determining the appropriate suppression systems and design densities needed in these areas (i.e., grouped cables and other mineral oil–based lubricating systems).

Given the fact that fire-resistant fluid still has the ability to burn, care should be exercised in selecting the fluid. When selecting the fluid, consideration should be given to the fluid's heat release rate, fire point, and ability to sustain a spray or cascading fire once the ignition source is removed. The autoignition temperature of the fluid used should be sufficient to minimize the potential for a fire based on common ignition and heat sources located in the turbine generator area.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

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Organization: Ge Power & Water

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Committee: ECG-AAA

Public Comment No. 40-NFPA 850-2018 [Section No. A.9.8.6]

A.~~9~~ 10 .~~8.6~~ — 3.1.4.1 __

On some turbine-generators employing the guard pipe principle, the guard piping arrangement terminates under the machine housing where feed and return piping run to pairs of bearings. Such locations are vulnerable to breakage with attendant release of oil in the event of excessive machine vibration and should be protected.

Lubricating oil system designs should reflect a design objective to minimize the amount of oil needed and the amount of piping and associated components necessary.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

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Public Comment No. 33-NFPA 850-2018 [Section No. A.9.8.9.1]

A.9. 10.3.1.5. 8.9. 1

If the lubricating oil reservoir is elevated, sprinkler protection should be extended to protect the area beneath the reservoir.

If the lubricating oil reservoirs and handling equipment are located on the turbine operating floor and not enclosed in a separate fire area, then all areas subject to oil flow or oil accumulation should be protected by an automatic sprinkler or deluge system.

Statement of Problem and Substantiation for Public Comment

Annex material moved from Chapter 9 to follow the source reference material as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

- First Revision No. 12-NFPA 850-2018 [Global Input]

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: Ge Power & Water
Street Address:
City:
State:
Zip:

Submittal Date: Wed Nov 07 14:17:33 EST 2018
Committee: ECG-AAA

Public Comment No. 26-NFPA 850-2018 [Section No. A.10.1.3]

A.10.1.3 — 4

Although it is intended that these recommendations are to be applied to fixed, non-residential ICEs only, larger portable units (often trailer mounted) can include fire detection and suppression systems to limit damage from fire. The recommendations of this chapter can be used as guidance for these units as well.

Statement of Problem and Substantiation for Public Comment

Annex material changed as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10 which moved the reference material location. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 14-NFPA 850-2018 [Section No. A.10.3.2.1]

A.10.3.2.3. 1

When a flameout occurs, fuel valves should close as rapidly as possible to preclude the accumulation of unburned fuel in the combustion chamber. Loss experience documents that fires or explosions have occurred in systems where the fuel isolation was not achieved within 3 seconds.

Statement of Problem and Substantiation for Public Comment

Complimentary change to Public Comment 13 that modified the location of the primary text. This is a follow-on reorganization in the spirit of the First Revision 12 effort.

Related Item

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Public Comment No. 31-NFPA 850-2018 [Section No. A.10.3.3.2]

A.10.3.~~3.2~~ — <u>1.4.7</u> __

Internal combustion engines do not normally have any hydraulic systems.

Statement of Problem and Substantiation for Public Comment

Annex material location changed as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10 which moved the reference material location. This reorganization is in the spirit of the First Revision 12 effort.

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Public Comment No. 34-NFPA 850-2018 [Section No. A.10.3.5.1]

A.10.3.~~5~~ 1 .6. 1—

The use of less flammable filter or media in the CT air inlet is recommended where not constrained by other engineering needs (such as pressure loss across the elements) and cost considerations associated with UL 900 Class I (do not contribute fuel) versus Class II fire-resistant elements.

Statement of Problem and Substantiation for Public Comment

Annex material location changed as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10 which moved the reference material location. This reorganization is in the spirit of the First Revision 12 effort.

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Public Comment No. 38-NFPA 850-2018 [Section No. A.10.3.6.3]

A.10.3.~~6~~ 5 .3 — 10

ICE-powered generators are normally provided with an open drip-proof enclosure. Shielding might be needed when a water-based fire protection system is used.

Statement of Problem and Substantiation for Public Comment

Annex material location changed as part of the follow-on reorganization effort that combines Steam Turbine and Generator information from Chapter 9 into Chapter 10 which moved the reference material location. This reorganization is in the spirit of the First Revision 12 effort.

Related Item

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Submitter Full Name: Larry Danner

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Submittal Date: Wed Nov 07 14:29:22 EST 2018

Committee: ECG-AAA

Public Comment No. 41-NFPA 850-2018 [New Section after D.2]

Coal Plant - Flue Gas Desulfurization System

Three cases have been reported, where a large power station fire originating in the FGD system affected a borosilicate glass block lined steel chimney or steel chimney flue. The three fires have the following factors in common: (1) the fires occurred during a maintenance outage or during initial construction, (b) the fires resulted in very high temperatures within the steel chimney (flue) and (c) the borosilicate glass block lining, while itself heavily damaged, was successful in protecting the steel chimney (flue) against overheating and collapse.

Fire No. 1. This fire occurred in the FGD system of a coal fired power plant. As the fire erupted, very hot combustion gases entered into the stack, which was a 250 ft high, free standing steel stack internally lined with a lining of 1.5” thick borosilicate glass blocks. It was reported by power plant personnel that during the fire, flames erupted 10 to 15 feet above the top of the stack. Following the fire, it was established that the lining had been seriously damaged and needed partial replacement. The stack itself did not sustain structural damage.

Fire No. 2. This fire occurred in the FGD system of an oil fired power plant. The plant operates a 410 ft high concrete stack with three flues. The steel flue connected to the burning FGD system was internally protected by a lining of 1.5” thick borosilicate glass blocks. The heat entering this steel flue during the FGD fire was exacerbated by the fire in the fiberglass-reinforced plastic outlet duct connecting the FGD system to the stack. Following the fire, it was established that the lining had been irreparably damaged and needed complete replacement. The steel flue and the stack itself did not sustain structural damage.

Fire No. 3. This fire occurred in the FGD system of a coal fired power plant that was under (nearly complete) construction. The plant has a 689 ft high concrete stack with two flues. The steel flue connected to the burning FGD system was internally protected by a lining of 1.5” thick borosilicate glass blocks. During the fire, the steel flue was exposed to very hot combustion gases, with flames shooting out of the top of the stack. Following the fire, it was established that the lining had been irreparably damaged and needed complete replacement. The steel flue and the stack itself did not sustain structural damage.

Additional Proposed Changes

File Name	Description	Approved
Exponent_-_Chimney_fire_study.pdf	Exponent Study on large power plant fires	
I.R._01_131_-_Vasilikos_Power_Station_14.06.43.pdf	Vasilikos Power Station fire study	
I.R._01_132_-_Vinh_Tan_4_Power_Station_14.06.45.pdf	Vinh Tan 4 Power Station fire study	

Statement of Problem and Substantiation for Public Comment

The purpose for this informational inclusion is to provide historical data pertaining to past events and experiences for the reader of NFPA-850. By contributing these fire loss examples we can better educate the reader in real world situations which can and have occurred in the past. It is our hope that with this information it would help the reader in further assessing their current situation and also assist them in preparing for any potential future concerns.

Related Item

• FR-5-NFPA 850-2018 • C.5.3

Submitter Information Verification

Submitter Full Name: Gary Gerba
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Submittal Date:	Tue Nov 27 13:10:37 EST 2018
Committee:	ECG-AAA

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Failure Analysis Associates

Performance of Different Chimney Flue Designs During Large Power Plant Fires

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January 2005

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
FaAA	Failure Analysis Associates
FGD	Flue Gas Desulphurisation
FRP	Fiberglass Reinforced Plastic
KCPL	Kansas City Power & Light
MSCPA	Michigan South Central Power Agency
NFIRS	National Fire Incident Reporting System
Tg	Temperature of glass transition

About the Authors

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Dr. Jacques Bélanger is a Managing Engineer in Exponent's Thermal Sciences practice. Dr. Bélanger performs investigation and analysis related to fires and explosions. His expertise in those areas includes large-scale testing and computational simulation. He also works in the field of heat transfer, thermodynamics, and gas dynamics associated with gas releases and combustion processes. Dr. Bélanger has been involved in a number of investigations related to the flammability of fiberglass reinforced plastics used in different industrial applications. He is a registered professional mechanical engineer in the state of California.

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Executive Summary

This investigation was performed to evaluate the performance of different chimney flue designs when exposed to various fire conditions. The investigation involves both experimental testing and numerical modeling. The testing was performed to evaluate the performance of the Pennguard chimney flue lining system when exposed to different fire conditions. The numerical modeling was then used to reproduce the Pennguard lining behavior and compare its performance with other types of chimney flue designs.

The motivation for the investigation came from the realization that very little information is available regarding the fire behavior of the different types of chimney flue designs used today. In the last 20 years, a number of power plant chimneys have suffered severe fire damage, and in one case, in 1995, the fire caused partial collapse of the chimney flue. In another major fire in 1996, where a Pennguard lining system was used, the structural steel frame of the flue ended up being well protected by the lining and the fire resulted in no structural damage. With an average of about 60 structural fires per year in power plants reported by the National Fire Incident Reporting System (NFIRS) in the United States, the risk of chimney fire is real.

The first test performed follows the protocol described in the ASTM E-119 *Standard Test Methods for Fire Tests of Building Construction and Materials*. The test was run for more than two hours with the Pennguard blocks exposed to temperatures in excess of 1000^{o}C (1832^{o}F) in the latter part of the test. The test demonstrated the excellent thermal protection properties of the blocks at those high temperatures. Superficial melting of the exposed surface occurred, but the integrity of the wall behind the lining was never compromised. With the structural steel temperature never exceeding 240^{o}C (464^{o}F), it is clear that the blocks were able to protect the steel from heat damage for the entire duration of the two-hour test.

The second set of tests was demonstrative in nature and designed to evaluate the fire propagation properties of the adhesive used in the joints between the Pennguard blocks.
The results of this set of tests indicated that a localized ignition of the Pennguard adhesive on a vertical wall would not propagate away from the initial location of the flames. Furthermore, a few squirts of a water spray bottle were sufficient to extinguish the flaming joints.

The numerical model showed good agreement with the experimental measurements indicating that the thermal properties of the Pennguard wall are well known even at high temperatures encountered during fires. The model was also used to investigate two commonly used flue construction types in fire conditions; one built with a C276 alloy cladding and the other one made of Fiberglass Reinforced Plastic (FRP). The model demonstrated the weaknesses of these two modern chimney flue designs with respect to fire-protection of the structural components of the flue.

1. Introduction

This report presents the results of an investigation into the performance of different chimney flue designs when exposed to various fire conditions. The investigation involved both experimental testing and numerical modeling. The testing was performed to evaluate the performance of the Pennguard chimney flue lining system when exposed to different fire conditions. The numerical modeling was then used to reproduce the Pennguard lining behavior and compare its performance with other types of chimney flue designs.

The motivation for the investigation came from the realization that very little information is available regarding the fire behavior of these different types of chimney flue designs. This is regardless of the fact that power plant fires can cause severe chimney damage and in at least one case, in July 1995, a fire caused a chimney flue partial collapse[1,2]. In another major fire in April 1996, where a foamed borosilicate lining system was used, the structural steel frame of the flue was sufficiently protected by the lining and the fire resulted in no structural damage[3,4]. In that incident, only partial replacement of the lining turned out to be necessary.

Different types of chimney flue lining systems can be used in power plants to protect the structural components of the chimney against heat and corrosive gases present in the exhaust stream. This corrosion protective lining is particularly important in coal burning power plants using flue gas desulfurization (FGD) systems. These FGD systems are used to remove sulfur dioxide from the exhaust stream, but usually create a stream that can generate very corrosive condensates. Furthermore, these systems are usually located immediately upstream of the chimney and contain sufficient amounts of combustible construction materials to generate major fires.

One of the chimney flue lining systems used in power plants to protect against both the heat and the corrosive effects of the exhaust stream is the Pennguard lining system. The foamed borosilicate glass used to manufacture the Pennguard blocks provides both corrosion protection and thermal insulating properties. In theory, these combined properties should provide protection to the structural components of the chimney in case of a fire. However, prior to the present effort, the lining system had never undergone laboratory testing in actual fire conditions. Exponent was asked to perform the testing and use the data to compare the Pennguard system with other commonly used chimney flue linings.

Two commonly used alternative systems include a chimney flue made entirely of fiberglass reinforced plastic (FRP) and a system where a structural carbon steel flue is covered internally with a cladding of corrosion resistant Nickel alloy (C-276 or C-22). Neither one of these lining

[1] National Fire Incident Reporting System (NFIRS) data related to the incident.

[2] Private communication with Mr. James Krumm, retired Kansas City Power & Light (KCPL) La Cygne Station employee.

[3] Private communication with Mr. John Novak, the Power Production Superintendent at the plant at the time of the fire.

[4] Chimney inspection report, “Michigan South Central Power Agency Litchfield, Michigan”, International Chimney Corporation, May 28, 1996.

systems are designed to provide significant thermal protection to the structural components of the chimney.

The objective of this work was to quantify the fire protection provided by the Pennguard system and compare it to the other two alternatives. A standard fire test was selected as the preferred method of evaluating this characteristic. The chosen test is the ASTM E-119 *Standard Test Methods for Fire Tests of Building Construction and Materials*. Following the test, numerical modeling of the heat flux through the Pennguard lining was performed and validated using the experimental data. The model was subsequently used to compare the Pennguard lining with the other two systems.

The report is divided into four sections. The first section looks at historical data related to fires in power plant chimney flues. The section provides selected details about incidents directly related to the present investigation. The second section presents the laboratory fire exposure test results. The third section presents the modeling validation results and the comparison done with other types of chimney flue construction. The last section is a general discussion of the results with overall conclusions.

2. Power Plant Chimney Flue Fires

More than a thousand structural fires in power plants were reported in the United States by the National Fire Incident Reporting System (NFIRS) between 1983 and 1998[5]. This represents an average of about 60 structural fires in power plants in the United States per year during that period. A number of those structural fires resulted in chimney damage and in at least one case, at the Kansas City Power & Light (KCPL) La Cygne Station fire on July 1, 1995, the fire caused a partial collapse of the chimney flue. According to the NFIRS database, the La Cygne Station fire and six other fires during that 1983 to 1998 period were determined to have originated in the area of the chimney of the power plant. Because of the voluntary and often incomplete nature of the collection of NFIRS data, these seven incidents likely represent an incomplete listing of the total number of power plant fires that involved chimney flues over that same time period.

According to the information available, the fire at the La Cygne Station started in the FGD system. The FGD outlet duct and steel chimney flue were internally lined with an organic coating system. The coating system is believed to have caught fire, generating enough heat in the chimney flue to weaken the steel. As a result of the weakening of the steel, the 720 feet tall steel flue buckled at approximately the 230 feet level causing a partial collapse of the flue. Replacement of the lower 400 ft of the chimney flue was required. The chimney repair ended up being the most time consuming part of the repair project. It took 12 weeks of around the clock work to refurbish the chimney.

On April 27, 1996, less than a year after the La Cygne fire, another major fire in an FGD system occurred at the Endicott station in Michigan. At one point during the fire, Rob Morris, a Michigan South Central Power Agency (MSCPA) employee, reported flames 10 to 15 feet above the cone on the top of the 250 feet chimney[6]. Because of the height, design, and layout of the FGD unit and ductwork, the fire department was unable to effectively fight the fire and focused instead on protecting the other nearby structures[7]. The fire was finally extinguished by restricting airflow into the FGD unit, but not before most of the combustible material inside the FGD unit had been consumed by the fire[8]. In that case, the chimney flue was protected by a Pennguard lining system, and although the lining suffered damage due to the heat of the fire, the chimney survived. Figure 1 shows typical surface damage to the Pennguard lining after the fire. As a result of the thermal protection provided by the lining, the chimney did not collapse and significant savings of time and money during the repair of the power plant were realized.

[5] The last year for which data are available.

[6] Triodyne Fire & Explosion Engineers, Inc. fire cause and origin report dated July 19, 1996, pg 4.

[7] Private communication with Mr. John Novak, the Power Production Superintendent at the plant at the time of the fire.

[8] Triodyne Fire & Explosion Engineers, Inc. fire cause and origin report dated July 19, 1996, pg 4.

Figure 1. Surface damage to the Pennguard lining after the 1996 Endicott station fire. The photo was taken inside the chimney at an elevation of 140 feet.

3. Pennguard Lining System Fire Exposure Tests

Two sets of tests were performed to determine the behavior and endurance of the Pennguard lining system in different fire exposure situations. The first test involves exposing a wall section to a pre-determined set of fire exposure conditions, in order to simulate the effect of a fire on the underlying structural material. The test performed follows the protocol described in the ASTM E-119 *Standard Test Methods for Fire Tests of Building Construction and Materials*. The test was run for two hours with the Pennguard blocks exposed to temperatures in excess of 1000^{o}C in the latter part of the test. A description of the test and a discussion of the results are presented in the following section.

The second set of tests was demonstrative in nature and particularly designed to determine fire propagation properties of the exposed surface of the Pennguard lining system. The Pennguard blocks themselves are made of borosilicate glass and do not burn or propagate fire, but the adhesive used in the joints between the blocks is made of a combination of petroleum and plastic products that are combustible. The goal was to determine if a small fire capable of igniting the adhesive could propagate along the joints and result in a major fire inside a chimney flue covered with Pennguard lining. This type of testing would be representative of an accident where hot work performed near or inside the flue accidentally ignites the adhesive in a localized area. The results of these demonstrative tests are discussed in the section that follows the ASTM E-119 test results discussion.

3.1 ASTM E-119 Standard Test

This standard test is used by the building industry to officially determine the time for which a wall assembly could contain a fire and retain its structural integrity. The test performed in the present investigation involves a wall section of the Pennguard lining system mounted on a ¼-inch carbon steel plate according to typical installation procedures. During the test, the wall was exposed to a standard time-temperature curve reproduced in Figure 2. This time-temperature curve represents a severe fire condition with air temperature inside the furnace exceeding 500^{o}C (932^{o}F) less than 5 minutes into the test and 1000^{o}C (1832^{o}F) just before the end of the test. This temperature at the end of the test is sufficient to melt most copper alloys, a condition that is not often met even in actual large-scale fires.

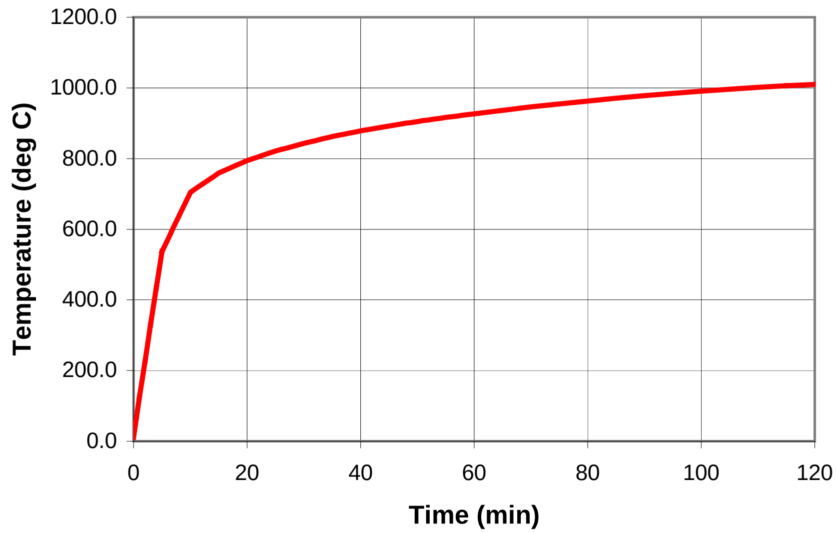

Figure 2. Furnace time-temperature curve for a two-hour ASTM E-119 standard test

The carbon steel plate used for the construction of the lining test wall is typical of the structural material used in chimney flue construction. To build the wall, an organic primer is first applied to the steel plate mostly for corrosion protection, but also to provide a good surface for the adhesive membrane. An adhesive membrane layer of about 0.125-inch is then applied to the primer surface and the blocks are then installed. The adhesive is also used to seal the small joints between the blocks. The assembly was left to dry for about one week before the test was performed. Figure 3 shows the completed 5 feet tall and 6 feet wide Pennguard wall assembly just before it was set in place for the test.

Figure 3. Pennguard lining wall before the ASTM E-119 test

The wall was instrumented with thermocouples to measure the temperature of the exposed surface of the Pennguard blocks and of the backside of the steel plate. An attempt to measure the temperature at other locations inside the blocks was unsuccessful due to installation difficulties that rendered the measurements uncertain and unreliable. The plot shown in Figure 4 presents the temperature measurements of the air inside the furnace, the surface of the Pennguard wall, and the backside of the steel plate for the two hours of testing. With the air furnace temperature sensors located inside protective steel tubes, these sensors turned out to have very slow time response. As a result of this slow response time, these air temperature measurements under-predict the actual temperature during the fast ramp up in temperature occurring in the first 20 minutes of the test. This under-prediction is clearly visible on the plot in the early part of the test when the air temperature measurements is, according to the data, lower than the temperature of the surface of the Pennguard wall. Overall, the plot shows good thermal resistivity of the Pennguard blocks even when their surface temperature approaches 900^{o}C (1652^{o}F). With the steel temperature never exceeding 240^{o}C (464^{o}F) during the two-hour test, it is clear that the blocks were able to protect the structural steel from heat damage over the entire duration of the test. At a temperature below 240^{o}C (464^{o}F), the steel will not have suffered any heat damage and the loss of yield strength would have been negligible.

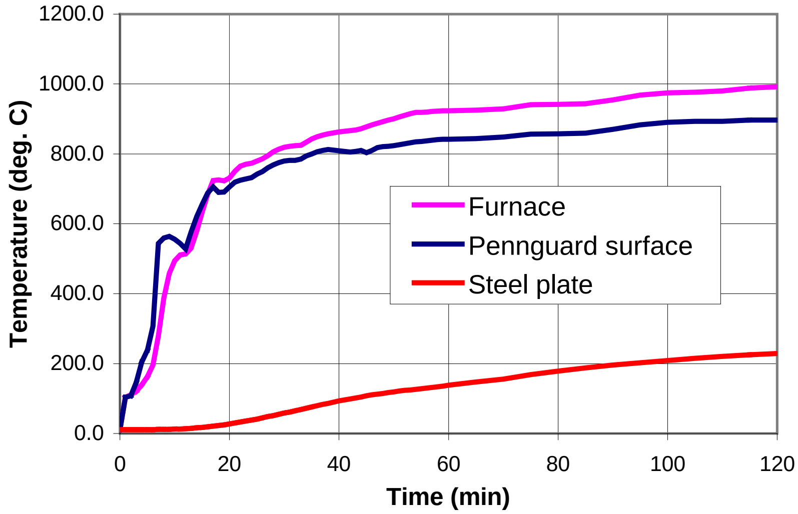

Figure 4. Temperature measurements during the ASTM E-119 test

Figure 5 shows the condition of the Pennguard wall after the test. The exposed surface of the blocks shown in the picture has been superficially melted and the adhesive had been partially consumed, but the integrity of the wall has not been compromised. The overall appearance of the surface of the wall is similar to the one found after the fire at the Endicott station shown in Figure 1. The similarity in the surface damage between the test and the actual fire is indicative of the severity of the fire that occurred at the Endicott station. Figure 6 shows the undamaged organic primer coating on the surface of the steel plate after the removal of some of the blocks in the center section of the wall. This is further indication that the carbon steel used for the structural part of the wall was not damaged by the fire test.

Figure 5. Pennguard wall after the ASTM E-119 test

Figure 6. Pennguard wall after the ASTM E-119 test showing the condition of the primer coating of the steel plate

3.2 Fire Propagation Test

For this set of tests, two small sections of Pennguard lining wall were constructed. The two wall sections are about 5 feet tall and 18 inches wide and represent two typical block assembly patterns. The two wall sections are shown in Figure 7 mounted over the gas burners used during these tests. The wall section on the left represents an assembly with aligned blocks and the one on the right represents the more common staggered assembly where the joints are discontinued on the vertical plane.

Figure 7. Two small wall sections of Pennguard lining mounted over the burners before the fire propagation test

Three tests were performed, two to investigate the flame propagation along the joints and one to determine if a fire in the joints could easily be extinguished. In each one of the tests, the burners were turned on to ignite the Pennguard adhesive located at the joints in the bottom section of the walls. Figure 8 shows the second flame propagation test in progress with the burners on. Figure 9 shows the burning joints for the same test just after the burners had been turned off.

Figure 8. Flame propagation test with the burners on

Figure 9. Flame propagation test after the burners were turned off

For both flame propagation tests, regardless of the construction type, the flames self-extinguished in eight minutes or less once the burners were turned off. The flame never propagated upward more than 12 inches following the turning off of the burner for the aligned joint and no more than two inches in the case of the staggered joint. The complete test results have been summarized and are shown in Table 1. For each test, the table includes the time the burner was on, the height of the flame when the burners were turned off, the height of the tallest flame, the total vertical flame progressions before extinction, and the time of extinction.

Table 1. Summary of flame propagation test results

Construction Method	Aligned Joints		Staggered Joints	
Test No.	1	2	1	2
Burner on (sec)	45	180	45	180
Initial flame height when burner turned off (in)	10	20	8	18
Maximum flame height (in)	15	32	10	18
Flame height progression (in)	5	12	2	0
Time of extinction (min)	4	8	5	7

The last test performed was done to determine how difficult it is to extinguish a joint fire. A simple hand pumped spray bottle was used for the experiment. It took only a few squirts of the spray bottle to extinguish the flaming joints. The test demonstrated that many types of suppression techniques could be used to control such joint adhesive fires, if they occur.

The results of this set of tests on flame propagation indicate that a localized ignition of the Pennguard adhesive on a vertical wall would not propagate away from the initial location of the flames. This is true even in the case where the wall has a continuous vertical joint. Furthermore, the application of nearly any available suppression technique would be sufficient to extinguish the flaming joints.

4. Fire Modeling Results

A numerical model was developed to reproduce the heat flux through the Pennguard wall for the ASTM E-119 test presented in the previous section. The goal was to verify that the heating process of the wall is well understood and that the thermal properties of the Pennguard blocks at those high temperatures are known. The model was then used to apply the same fire conditions to other types of chimney flue construction design. The present work investigated two of these commonly used construction types; one built with alloy C276 clad carbon steel and the other one with a FRP wall construction providing both corrosion protection and structural support.

The comparison between the test data and the results of the modeling of the Pennguard wall is shown in Figure 10. Only one parameter in this modeling was set using the present set of test data, all the other parameters had been determined using available data and known correlations. That parameter, the convective heat transfer coefficient between the furnace air and the Pennguard wall, could not be empirically determined due to uncertainties in the radiative component of the heat transfer inside the furnace. The value of the parameter was set so that the Pennguard wall surface temperature in the model matched the test data. As it can be seen in Figure 10, after the initial discrepancy generated by the under reported air temperature of the furnace, the model was then able to predict accurately the carbon steel plate temperature on the other side of the wall. This good agreement between the measurements and the model for the last hour of the test validates the model, and indicates that the thermal properties of the Pennguard wall components used in the model are well understood even at these high temperatures.

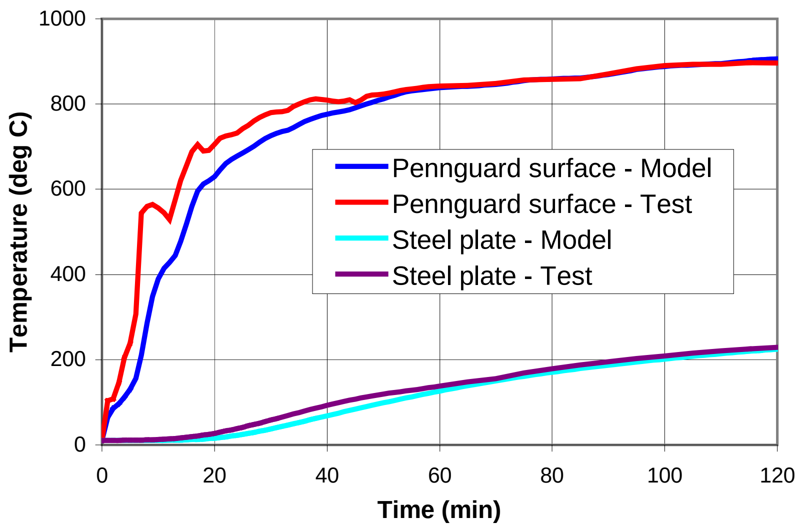

Figure 10. Comparison of the test data and the modeling results for the Pennguard wall test

The model was then used to investigate the thermal protection behavior of two commonly used flue construction systems under the same fire conditions. Figure 11 shows the results for the flue built of 0.25-inch carbon steel plate, internally clad with 0.0625-inch C276 alloy. Because the temperature of the alloy cladding is only a few degrees hotter than the steel plate, that temperature has not been reproduced in Figure 11. According to the model, the supporting steel plate would have reached a temperature of 550°C (1022°F) about 60 minutes into the test. A typical A-36 carbon steel plate at that temperature would have lost half its yield strength and the integrity of the chimney would be in jeopardy at that point in time. Even without yielding, the steel plate would have overheated by then and permanent damage to both the steel and the alloy cladding would have occurred.

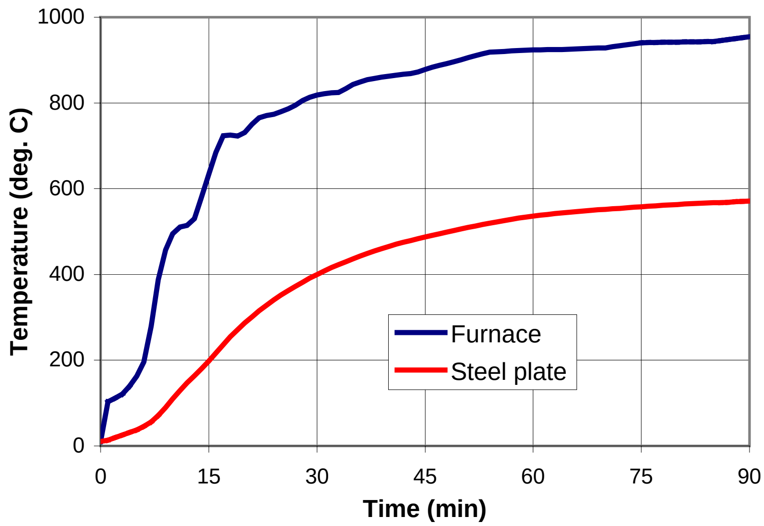

Figure 11. Modeling of the ASTM E-119 test with an alloy clad carbon steel flue

Figure 12 shows the modeling results for a typical FRP chimney flue with a 0.75-inch thick wall. According to the model, the FRP located on the backside of the flue would have reached a temperature of 200°C (392°F) about 30 minutes into the test, and the temperature at the midpoint of the FRP wall would have reached 200°C (392°F) about 20 minutes into the test. This 200°C (392°F) is a higher temperature than the glass transition (Tg) for FRP used in this type of application. The molecular structure of the FRP changes from that of a rigid crystalline polymer to a more flexible, amorphous polymer when this Tg temperature is reached. This change in the molecular structure produces a sharp drop in the resin modulus (stiffness), and in the compressive and shear strength of the composite. Therefore, with liner temperatures exceeding 200°C (392°F) for half to all of the wall thickness, the integrity of the chimney would be seriously jeopardized within 20 to 30 minutes.

Furthermore, there are always serious concerns regarding the combustibility of the FRP products. With the FRP located on the furnace side of the wall reaching a temperature of about 500°C (932°F) at about the 25-minute mark, it is clear that composite material will be decomposing and providing fuel to the fire. It is also possible that a combination of a partial structural collapse, like in the La Cygne Station fire, and the combustibility of the FRP flue could generate a situation where the fire would propagate outside the flue where more fuel and fresh air is available. This is true even if a flame retardant, like antimony oxide, is being used in the formulation of the FRP. These types of flame-retardants can reduce the production of the combustible gases and reduce the flame spread characteristics of the FRP by promoting the formation of “char”, but cannot prevent the decomposition process of the FRP when exposed to high temperatures generated by a large fire.

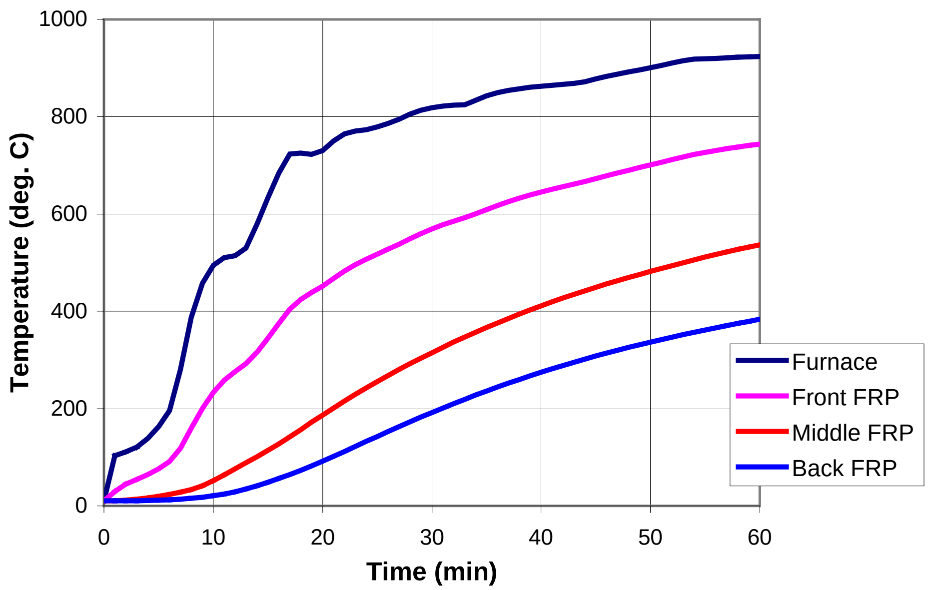

Figure 12. Modeling of the ASTM E-119 test with a FRP flue construction

5. Discussion

The present investigation demonstrated the following:

- The Pennguard lining system provided excellent thermal protection of the structural steel outer wall under the conditions of the ASTM E-119 *Standard Test Methods for Fire Tests of Building Construction and Materials*.
- During the two-hour ASTM E-119 test, the structural steel temperature never exceeded 240^oC (464^oF), which clearly indicates that the Pennguard lining was able to protect the steel from heat damage over the entire duration of the test.
- The fire propagation tests indicate that a localized ignition of the Pennguard adhesive on a vertical wall would not propagate away from the initial location of the flames.
- The flame-extinguishing test, wherein only a few squirts of the spray bottle led to extinguishment, demonstrated that many types of suppression techniques could be used to control joint adhesive fires, if they occur.
- The numerical model shows good agreement with the experimental measurements indicating that the thermal properties of the Pennguard wall are well known even at high temperatures encountered during fires.
- The model was used to investigate the thermal protection behavior of two commonly used flue construction systems, one built with a C276 alloy cladding and the other one made of Fiberglass Reinforced Plastic (FRP). The modeling results demonstrated that these two chimney flue designs are ineffective at protecting the structural components of the flue in case of a fire.

Supervised by: E. Palmen

Report by: E. Palmen

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Protecting Power Plant Chimneys

Inspection report 01 131

EAC Vasilikos Power Station, Cyprus
Pennguard Block Lining System
in Unit 3 chimney flue

Rev. No.:	Date published:	Reference:	By: Initials:	By: Date:	By: Paraph:	Approved: Initials:	Approved: Date:	Approved: Paraph:
/	14-03-17	Original	ErP	14-03-17	[signature]	AdK	14-03-17	[signature]

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Inspection report

Subject: EAC Vasilikos Power Station, PBLS unit #3

Customer: Vasilikos Power Station, Cyprus
Date: 14-03-2017
Reference: M.R. 08 - 033

1 Introduction

Vasilikos Power Station is a heavy oil fired electrical power station with 3 units of each 130 MW. Units 1 and 2 were commisioned in 2000, without FGD. Unit 3 is equipped with a Sea Water FGD, with an FRP outlet duct. It was commisioned in 2004

The Pennguard Block Lining System 55 - 1,5" was installed in 2004. Hadek Protective Systems performed QA/QC supervision during the installation of the Pennguard linings in the flue. For additional information I refer to Manufacturing Report 08-033, with more details on the original installation.

After an unfortunate fire in the FGD of Vasilikos Power Station in November 2016, Hadek received a request for a visit and an inspection of the Pennguard lining system in the Unit 3 chimney flue. An inspection was carried out on the 24th and 25th of Febuary 2017.

For the inspection, the contact person was Mr Phivos Koumides, Assistant Station Manager and Senior Engineer Mechanical Maintenance.

01 - Vasilikos Power Station with on the left the chimney for units 1, 2 and 3

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Inspection report

Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

Customer: Vasilikos Power Station, Cyprus
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Reference: M.R. 08 - 033

02 - heavily damaged FGD plant, FRP outlet duct completely destroyed

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Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

Customer: Vasilikos Power Station, Cyprus
Date: 14-03-2017
Reference: M.R. 08 - 033

2 Design & construction

2.1 Substrate

The flue has a lenght of approximately 117 meters inlcuding bend. The flue and the bend are made out of Corten steel . The upper 6 meters of the flue, which protrude above the concrete windshield, are made out of 6 mm thick stainless steel, internally Pennguard lined.

2.3 Layout and dimensions

The chimney has a concrete windshield with a lenght of approximately 120 m above ground level, equipped with 3 flues which all protrude 6 meter above the windshield.

Only one flue, used for Unit 3, is lined with Pennguard Block Lining System. As for all Pennguard lined steel flues, the Unit 3 flue has NO external insulation.

Drawing 1 shows the dimensions of the chimney.

2.2 Lining specifications

The Pennguard Block Lining System, as installed in 2004, is shown in Table 1.

No.:	Section	Lining specification	Area in m2
1	Vertical flue	Pennguard 55 - 1.5"	1.032
2	Elbow	Pennguard 55 - 1.5"	78
		Total installed Pennguard 55 - 1.5"	1.110

Table 1: lining specification

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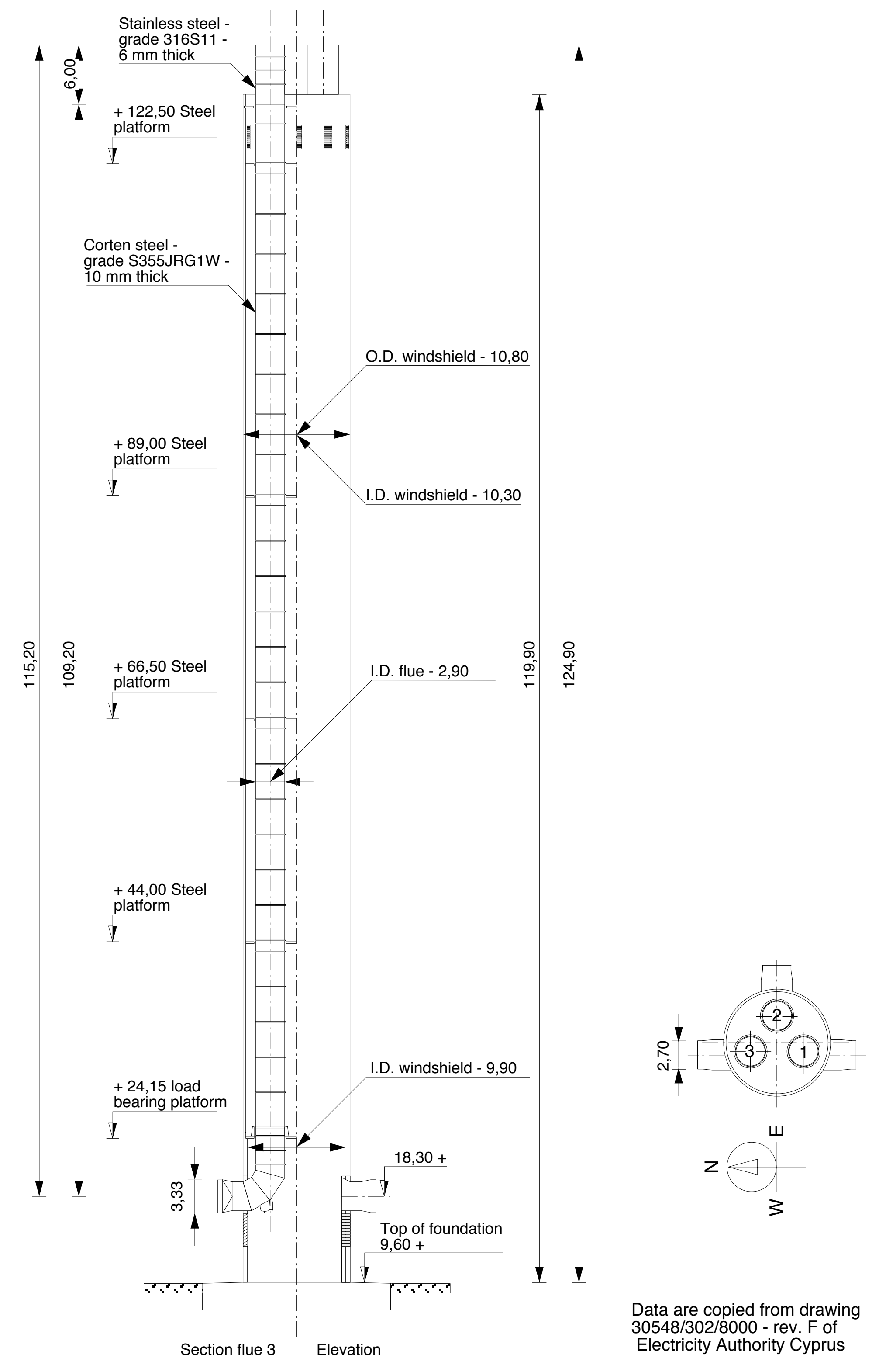
Manufacturing report

Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

Customer: Vasilikos Power Station, Cyprus
Date: 14-03-2017
Reference: M.R. 08 - 033



Drawing 1: dimensions of Chimney with flue unit 3

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3 Operating conditions

Normal operation :

- Flue gas tempearture leaving the FGD 90°C, approximately 83 °C in the flue.

- By-pass temperature between 120 °C and 125 °C, to a maximum of 130°C.

Between the installation in 2004 and November 2016, Unit 3 has been in service for approximately 74000 hours.

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Inspection report

Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

Customer: Vasilikos Power Station, Cyprus
Date: 14-03-2017
Reference: M.R. 08 - 033

4 Set up for inspection

4.1 Access

To reach the flue, a scaffolding was built with regulair scaffolding stairs. For access into the flue, EAC hired specialist company Zenith Structural (UK).

Zenith installed a 2 persons motorised cradle access system including a stop-block on a double wired system; one wire for actual use and one safety wire.


03 - scaffolding to access front of the bend

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4.2 Safety

Safety induction was provided by EAC and "toolbox meetings" were held each morning by Zenith.

Besides standard PPE including safety helmets, -shoes and -glasses, all personnel had to wear a safety harnesses when riding the cradle. The cradle was operated by a licenced operator from Zenith.

The cradle was suspended with a double wired system; one wire for actual movement and one for safety, going through a stopblock type BSO (Block Stop Overspeed, an automatic clamping device of the wire by ovespeed detection).

A P&P Rescue kit, including among others a Descender assembled to a lenght of 200 meters of 11 mm mantled rope, was present all the time.

04 - 2 persons cradle suspended on a 2-rope system

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5 Inspection of the flue

The flue was visually inspected by two Hadek inspectors. The inside and outside surfaces were inspected simultaneously to identify and analyze any abnormality on either side of the steel flue.

The inspection was carried out firstly to establish the current condition of the Pennguard Block Lining System, following exposure to the fire and heat. The inspection was also aimed at checking for any impact on the integrity of the steel flue, and to determine whether more inspections would be needed.

The Pennguard Block Lining System was strongly affected by the fire and based on the information provided, and on the state of the Pennguard lining, it is believed that the fire in the FRP outlet duct was a major heat source.

The temperature to which the Pennguard Block Lining System was exposed is estimated to have reached 1300 °C. After the FRP duct collapsed, the temperature quickly lowered below the glass melting temperature and melting of the Pennguard Blocks came to a halt.

The Pennguard Blocks have been affected over the full height of the flue. The surface of all blocks has molten and flowed together and the integrity of blocks has been reduced. This could be easy established when cutting out Pennguard Blocks, which were very brittle.

The Pennguard Adhesive Membrane (PAM) side joints had been charred over almost the entire thickness of the Pennguard Blocks, almost to the back joint. The PAM behind the Pennguard Block, i.e. the back joint, was however in a state still moderately flexible.

The Pennguard Block Primer behind the PAM had not burned, and had not been affected in any other way, on any of the spot checks that were taken.

Inspection of the outside of flue, where extra attention was given to the support of the flue, did not reveal any visual abnormality. Hadek did not perform any NDT (Non Destructive Testing) on welds.

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Inspection report

Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

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Date: 14-03-2017
Reference: M.R. 08 - 033

05 - upwards view taken from lower part of the flue

06 - Pennguard lining at level of sample ports

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07 - spot check at +30 meters

08 - spot check at +60 meters with intact back joint Membrane and Primer

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09 - view upwards halfway up the flue, with molten Pennguard Blocks

10 - spot check at the top

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11 - outside of the 3 flues. On the left, without insulation, the Unit 3 flue.

12 - view bottom flue / bend with drainage

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13 - close-up of a support of the flue

14 - outside of flue 3, half way up

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6 General observations

The FGD installation has burnt out completely and the FRP outlet duct to the chimney, which connected the FGD absorber and the chimney, has collapsed during the fire.

After the FRP duct had collapsed, its remaining parts caused some damage on a chimney entrance below. The steel support structure for the duct is still present and intact.

On the portion of the steel chimney flue that protrudes above the concrete windshield, the coloured warning stripes are still present, indicating that the insulating effect of the Pennguard lining has protected the paint system from overheating during the fire.

13 - red-white warning stripes on the outside of the flue Unit 3 flue still present

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7 Experience by the customer

The Pennguard lining system in the Vasilikos Unit 3 chimney flue has functioned well, and without any maintenance, since its installation in 2004 and consequently, the customer had "forgotten" about the system.

Following the fire, it has been recognized that the Pennguard lining has played an important role in protecting the flue from any structural damage, through avoiding overheating and collapse.

It is important to note that a collapse of the Unit 3 flue would inevitably have damaged the Unit 1 and Unit 2 flues as well, possibly resulting in extended non-availability of all three units.

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Inspection report

Subject: EAC Vasilikos Power Station, PBLS Unit 3 chimney flue

Customer: Vasilikos Power Station, Cyprus
Date: 14-03-2017
Reference: M.R. 08 - 033

8 Conclusion and recommendations

The fire in the FGD system, including the burst of heat caused by the fire of the FRP outlet duct, has caused severe damage to the Pennguard Block Lining System inside the Unit 3 chimney flue. The Pennguard Block Lining System has been affected to an extent that it is no longer a reliable corrosion protection and it needs to be replaced.

The Unit 3 steel chimney flue, however has survived intact as it was completely protected by the insulating capacity of the Pennguard lining system.

The owner wishes to have Unit 3 back in service as soon as possible, prior to the commissioning of a new FGD. After resuming operation without FGD, the chimney flue will be exposed to flue gas of around 125 °C. A new Pennguard Block Lining System must be installed prior to renewed use of the flue, with gas temperatures of approximately 125 °C.

The original Pennguard lining, which used 38 mm thick Pennguard Block 55, was exposed to FGD Bypass temperatures only short periods at a time. In the new, temporary situation when Unit 3 operates without FGD, the power generating unit will be connected straight to the flue and will expose the protective lining to a constant flue gas temperature of around 125 °C over longer periods of time. To protect the steel chimney flue under these conditions the owner has been advised to install a Pennguard lining using 51 mm thick Pennguard Block 55, with the additional thickness providing sufficient lining system durability under high temperature conditions.

Rotterdam, 14 March 2017

Erik Palmen

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Supervised by: S. Chan

Report by: S. Chan

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Protecting Power Plant Chimneys

Inspection report 01 132

Inspection of Pennguard™ Block Lining System on the steel chimney flue of Unit 1 at Vinh Tan 4 Power Station, Vietnam

Rev. No.:	Date published:	Reference:	By: Initials:	By: Date:	By: Paraph:	Approved: Initials:	Approved: Date:	Approved: Paraph:
/	30-03-17	Original	StC	30-03-17	[signature]	CeV	30-03-17	[signature]

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Inspection report

Subject: Vinh Tan 4 Power Station unit #1
Inspection of Pennguard™ Block Lining System
Customer: Doosan Heavy Industries & Construction
Date: 30-03-2017
Reference: 2014928.Pe / M.R. 08 137

1 Introduction

Vinh Tan 4 Power Station is part of the Vinh Tan Power Complex located at Binh Thuan province, about 250 km NE of Ho Chi Minh city.

The station is coal fired with two supercritical steam parameter boilers, installed capacity of 1200MW (2x600MW), total generation of 7.2 billion KWh per year.

Photo 1: Vinh Tan 4 Power Station during construction phase

Vinh Tan 4 is built under EVN's investment. The EPC contract was awarded to a consortium of Doosan, Mitsubishi, Pacific JSC and PECC2. The latter two are Vietnamese companies. Within the power sector, this is the first EPC contract where a domestic consultant company (PECC2 in this case) participates as a

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member of a Consortium of Contractors. Another EVN consulting company, PECC3, has been appointed as the Consultant for the Investor, in collaboration with foreign auxiliary consulting companies.

December 2014, Hadek received the original signed contract of CRI for the delivery of materials for Vinh Tan 4 Power Station, Vietnam. The purchase order for the supply of technical assistance was received on 2 November 2015.

The installation of the Pennguard Block Lining System started on 12 November 2015 and was finished on 27 April 2016.

On 7 March 2017 an intensive fire occurred in the Unit 1 FGD (Flue Gas Desulphurisation) plant. The fire spread itself downstream of the FGD towards the Pennguard lined steel flue. The exact cause of the fire in the FGD is unknown. Hadek representative Steve Chan inspected the Pennguard lining on 16 March 2017.

This inspection report describes the technical performance and appearance of the Pennguard Block Lining System after the inferno. Several destructive tests were executed on Pennguard lining to verify the status.

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2 Design & construction

2.1 General

Vinh Tan 4 Power Station has 1 concrete chimney with two inner steel flues.

The height of the chimney is 213,5 meters. The internal diameter of each flue is approximately 6,43 meters.

Each unit is equipped with its own seawater FGD (Flue Gas Desulphurisation). To protect the inside of the steel flues from corrosion, the EPC contractor has installed the Pennguard Block Lining System.

2.2 Substrate

The Pennguard lining was applied on the inside surface of the carbon steel flues.

The top 2 sections were fabricated in stainless steel and also lined with Pennguard. These sections were connected to the carbon steel flue by bolts and nuts. Stop bars and sample ports were made of stainless steel.

2.3 Lining specifications

Table 1 summarizes the areas which are protected with the Pennguard lining.

No.:	Chimney part	Area to be protected (m^2)
1.	Flue wall unit #1	3.334,00
2.	Elbow piece unit #1	250,00
	Total lined area of unit #1 chimney flue	3.584,00

Table 1: lining specification and overview of areas of Unit #1

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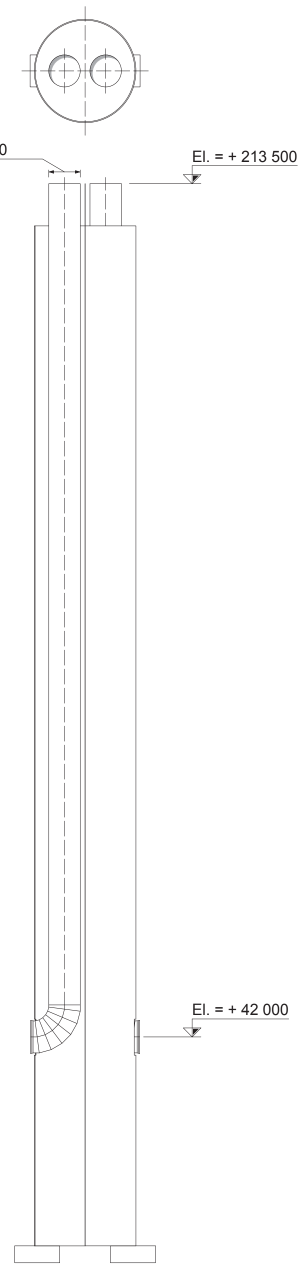
2.4 Layout and dimensions

Drawing 1 shows a schematic overview of one chimney flue.



Drawing 1: schematic overview of flue

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3 Operating conditions

Firing of the Unit 1 boiler with Light Diesel Oil (LDO) was completed successfully before the accident. Coal firing was planned for 31 March 2017.

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Inspection report

Subject: Vinh Tan 4 Power Station unit #1
Inspection of Pennguard™ Block Lining System
Customer: Doosan Heavy Industries & Construction
Date: 30-03-2017
Reference: 2014928.Pe / M.R. 08 137

4 Set up for inspection

4.1 Access

During this inspection, access was via the regular inspection doors at several landings. The top of the flue was reachable via the external platform.

Photo 2: inspection door at chimney inlet duct E.L.42 m

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Photo 3: inspection door at the top of the chimney

Photo 4: inspection door at landing 3 E.L. 127,2 m

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4.2 Safety

All regular safety measures were taken during the inspection. Doosan had implemented strict access control measures. Any person or vehicle entering or exiting the construction site must have a valid gate pass.

The following PPE had to be worn at all times when entering site:

- overalls;
- safety glasses;
- safety shoes;
- gloves;
- hard hat;
- high visible vest;
- full body harness.

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5 Inspection of the flue

The flue was inspected visually and by means of destructive testing to determine the actual status of the Pennguard Block Lining System after the fire accident in the FGD. Doosan staff assisted Hadek's inspector for this inspection during all times.

The fire started in the FGD, therefore the flue inlet was inspected first. After entering the inspection door of the flue inlet duct, it was evident that the intense fire had affected all the lining materials. All combustible materials in the FGD were burned completely.

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The Pennguard Blocks in the elbow had a molten/ glazed appearance. The Pennguard Adhesive Membrane in the joints was charred over 50% of the thickness of the lining system. No detached Pennguard Blocks were found in the bottom of the elbow.

The temperature to which the Pennguard Block Lining System was exposed is estimated to be 1000°C. Due to the burned holes in the expansion joint a huge amount of air was available to feed the fire in the FGD. After all combustible materials in the FGD were burned the fire inside the Pennguard lined flue, extinguished itself. Although the fire in the FGD lasted for approximately 20 minutes, the damages are severe.

The temperature inside the steel flue has reached temperatures far above the threshold of the CEMS (Continuos Emission Monitoring System) during the fire, that is why no clear data is available.

Destructive testing was executed to verify the condition of the Pennguard Block Lining System. In order to find out which part of the lining was still intact the focus was on Pennguard Blocks, Pennguard Adhesive Membrane (PAM) and Pennguard HP Epoxy Primer.

All the Pennguard Blocks in the entire flue are affected. The surface of all blocks has molten. The heat of the fire affected the strength and structure of the Blocks negatively. Blocks were cut out at several heights.

The PAM of the exposed joints had been charred to the inside, for over 50% of the thickness of the Pennguard Blocks. The PAM behind the Pennguard Block, i.e. the back joint, was in good condition. No loss of flexibility or adhesion properties were observed.

The Pennguard HP Epoxy Primer on the steel substrate was in good condition in areas where sampling was conducted. No discolorations by heat or detachment of the primer was noted.

Although the heat melted the Pennguard Blocks and charred the joints on the exposed side, the insulating properties of the Pennguard Blocks minimized the heat transfer to the back joint. The flexible Pennguard Adhesive Membrane on the back joint and unaffected Pennguard HP Epoxy Primer double confirms that the steel flue was well protected during the fire accident.

Inspection of the outside of the flue, where extra attention was given to the support of the flue, did not reveal any visual abnormality. Hadek did not perform any NDT (Non Destructive Testing) on welds. On all areas where the Pennguard Block Lining System was installed, no burning/ heat marks were found on the external paint. Further, no damages were found to equipment on the landings inside the windshield. On the top of the chimney some equipment was damaged due to the radiation heat of the open flames.

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Photo 5: Pennguard lining at drainbox, loose blocks due to traffic

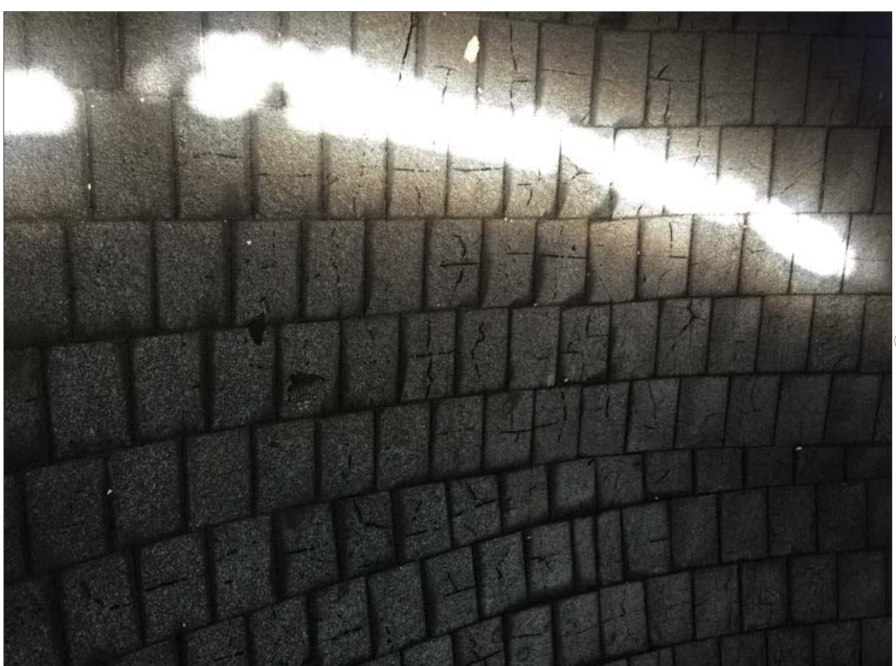

Photo 6: molten and cracked Blocks in the elbow

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Photo 7: spot check target wall


Photo 8: close up spot check target wall

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Photo 9: elbow of unit #1 on the left, no discoloration of external paint

Photos 10: destructive testing of lining at inspection door of chimney flue

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Inspection report

Subject: Vinh Tan 4 Power Station unit #1
Inspection of Pennguard™ Block Lining System
Customer: Doosan Heavy Industries & Construction
Date: 30-03-2017
Reference: 2014928.Pe / M.R. 08 137

Photo 11: general overview of molten PBLS at top section

Photo 12: top Stopbar unit #1 (front), top section unit #2 (back)

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Photo 13: molten PBLS at CEMS level

Photo 14: exterior steel liner unit #1 at CEMS level

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6 General observations

Combustible materials in the FGD have burned completely. The flue gas path downstream of the FGD was exposed to extreme temperatures. To avoid any backdraft, no fire fighting could be done inside the FGD when the fire was discovered. By cutting off the oxygen supply, the fire was under control and basically extinguished itself after all oxygen and combustibles were burned.

The Pennguard Blocks and Pennguard Adhesive Membrane protected the steel flue very well during the fire. Although the PBLS is damaged, the insulating properties did a good job. There was no damaging heat transfer from the fire exposed side to the backside, nor was there any conduction or radiation of heat which could have damaged equipment in the windshield.

Photo 15: external paint of steel liner without damages by fire/ heat

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7 Experience by the customer

Unfortunately the fire accident in the FGD resulted in damaged plant sections and delay of power production.

Doosan engineers acknowledge that the Pennguard Block Lining System has protected the steel liner from overheating. They fully understand that the remaining properties of the Pennguard Block are compromised after the fire, and repairs are needed.

Photo 16: Doosan engineers are opening inspection door for inspection

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HADEK
Protecting Power Plant Chimneys

Inspection report

Subject: Vinh Tan 4 Power Station unit #1
Inspection of Pennguard™ Block Lining System

Customer: Doosan Heavy Industries & Construction

Date: 30-03-2017

Reference: 2014928.Pe / M.R. 08 137

8 Conclusion and recommendations

The fire accident in Vinh Tan 4 unit #1 FGD has damaged the Pennguard Block Lining System in the steel flue. Destructive spot check testing of the Pennguard Block Lining System has shown that the Pennguard Blocks lost their original properties and structure.

It is obvious that the Pennguard Block Lining System has done a great job protecting the steel flue during the fire. However the Pennguard Block and Pennguard Adhesve Membrane have been irreversibly damaged and must be replaced.

We recommend an inspection of the top section of unit #2 to verify that exposure to heat from the external fire at the top of unit #1, has not locally affected the Pennguard lining of the top of this unit.

Since it is unclear what caused the fire in the FGD no recommendations can be given to avoid this from happening again. We would like to thank Doosan's Vinh Tan 4 site personnel for their support during this inspection.

Rotterdam, 30 March 2017

Steve Chan

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Attachment E: NFPA 853 Public Comment Report

Public Comment No. 1-NFPA 853-2018 [Section No. 4.2.2]

~~**4.2.2**~~

~~Prepackaged, self-contained fuel cell power systems outside the scope of ANSI/CSA FC 1, *Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety*, shall meet the provisions of Section 4.3.~~

Statement of Problem and Substantiation for Public Comment

All Prepackaged, self-contained fuel cell power systems are now within the scope of ANSI/CSA FC 1. Earlier additions of FC 1 were not inclusive of all stationary power plants. Revisions to FC 1 now include pre-packaged and self-contained power plants.

Related Item

- General Equipment Configuration

Submitter Information Verification

Submitter Full Name: Eric Prause
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Zip:
Submittal Date: Thu Nov 15 15:21:24 EST 2018
Committee: ECG-AAA

Public Comment No. 2-NFPA 853-2018 [Section No. 4.3]

4.3 Pre-Engineered and Matched Modular Fuel Cell Power Systems.

4.3.1

Pre-engineered fuel cell power systems and matched modular components (which are assembled on site) shall be designed ~~and tested to meet the intent of~~ , tested, and listed in accordance with ANSI/CSA FC 1, *Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety*.

~~**4.3.2**~~

~~Proprietary equipment or materials for which no generally recognized codes or standards exist shall be evaluated based on data from operational experience in the same or comparable service or test records covering the performance of the equipment or materials.~~

Statement of Problem and Substantiation for Public Comment

"Matched Modular" was missing from heading of Section 4.3.

Clarification needed regarding the definition of a matched module system. Added the existing clarification of matched module definition in Section A.3.3.12.2.

All Pre-engineered and matched module fuel cell power systems are now within the scope of ANSI/CSA FC 1. Earlier additions of FC 1 were not inclusive of all stationary power plants. Revisions to FC 1 now include these types of power plants. Removed Section 4.3.2 that allowed for alternate compliance.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 1-NFPA 853-2018 [Section No. 4.2.2]	

Related Item

- General Equipment Configuration

Submitter Information Verification

Submitter Full Name: Eric Prause
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Public Comment No. 3-NFPA 853-2018 [Sections A.4.1, A.5.1.1(5)]

Sections A.4.1, A.5.1.1(5)

A.4.1

Fuel cell technology is evolving ~~at a rapid rate, and codes and standards criteria are needed to help acceptance of the new technology. Currently, there is only one~~ . Early editions of the standard for testing fuel cell power systems, ~~which is~~ ANSI/CSA FC 1, *Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety*, limited designs by output power, fuels and construction techniques . ANSI ~~/~~ CSA FC 1 ~~applies to a specific size fuel cell power system that is prepackaged and assembled as one complete unit. The constraints~~ has matured so that its current edition has no limitation on output power, permits all credible fuels and fuel cell technologies, and allows designs packaged in a single enclosure or matched modules assembled on site. Outside the scope of ANSI/CSA FC 1 ~~limit the ability to test and list larger power plants or power systems that use fuels other than natural gas or LP-Gas or that are not prepackaged and self-contained.NFPA 853 provides additional guidance for acceptance of power system installations that are not within the scope of ANSI/CSA FC 1, commensurate with the need to protect life safety and property and the need of the adoption agencies to be able to uniformly evaluate power system installations outside the scope of available equipment standards.~~ are one of a kind designs possibly constructed on site. In the latter case, Engineered and Field-Constructed Fuel Cell Power Systems may be accepted at the site based on documentation, including a fire risk evaluation prepared by a registered engineer or third party acceptable to the authority having jurisdiction. See clause 4.4, Engineered and Field-Constructed Fuel Cell Power Systems.

A.5.1.1(5)

For additional information on hazardous atmospheres, see NFPA 497.

Statement of Problem and Substantiation for Public Comment

All Pre-engineered and matched module fuel cell power systems are now within the scope of ANSI/CSA FC 1. Earlier additions of FC 1 were not inclusive of all stationary power plants. Revisions to FC 1 now include all stationary power plants. Clarified that Pre-engineered and Field-Constructed units are accepted under Section 4.4.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 1-NFPA 853-2018 [Section No. 4.2.2]	

Related Item

- General Equipment Configuration

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