# Houston, We Have a Hazard

## Assessment & mitigation of critical boiler and machinery equipment failure

White paper


## Abstract

When it comes to the protection of critical equipment, regulatory compliance and industry standards only go so far. In order to avoid equipment failure and business interruption, companies must consider these risks before they occur, and implement a strategic risk management program to avoid such losses. This paper will discuss the importance of assessing Boiler and Machinery (B&M) risks and the steps that companies can take to address such hazards. Also explored will be B&M risk surveys in identifying potential vulnerabilities and in implementing best practices for B&M risk management.



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# 1. Introduction

The unexpected loss of critical boiler and machinery (B&M) equipment, including production and electrical equipment and utilities, can cripple any company's productivity and can have a major impact on its financial performance. In fact, major insurance providers have estimated that losses connected with B&M failures are two times greater than those incurred through fire-related losses.

In addition, property damage, environmental harm, and long replacement times for key mechanical components can quickly put a company out of business. Therefore, an organization's continued success relies on effective programs that can help to ensure equipment reliability and prevent failure.



# 2. The origins of industrial risk control

Historically, traditional property loss control has focused primarily on the risks associated with fire and explosions. This focus is understandable, given that almost any industrial facility, regardless of occupancy or use, is potentially susceptible to major loss due to a fire. A property risk survey will generally consider the potential exposure associated with fire losses but can often be extended to include other exposures such as natural catastrophes and other hazards.

In a standard property risk survey, the risk surveyor will evaluate, assess and document how a fire might develop, the likelihood of a loss, and the worst foreseeable outcomes consistent with generally accepted insurance industry definitions and assumptions.

Fire risk engineers perform a critical function in assessing property risks. They consider the broad range of causes behind fire inception and then evaluate the potential resilience of a given facility in mitigating the escalation and effects of such an event. Experienced fire risk engineers also consider the human element in potential fire risks, addressing diverse issues from the effectiveness of general housekeeping practices to the safe management of hot work installations.

The science of fire risk engineering is mature and well-understood. Organizations like the National Fire Protection Association (NFPA) and Factory Mutual Group (FMG) have developed a number of guidelines, standards and data sheets that can provide effective benchmarks for fire risk assessments. Internationally recognized, these guidelines and standards often exceed local regulations or standards and are therefore considered best practices in fire risk engineering.

Yet, as time (and more importantly, risks) have evolved, so too must property loss control programs.



Industrial fire protection systems were developed, in part, due to early risk management efforts related to fires and explosions.

# 3. Boiler and machinery risk engineering

The B&M risk engineering community is much smaller than that of fire risk engineers. Traditionally, B&M risk engineering efforts have largely focused on heavier industries, where the use of large, heavy-duty machinery and equipment presents significant additional risks. In some cases, the increased frequency of risk-induced events in these industries can contribute to a further drain on an organization's resources, even when such events fall below the threshold for an insurance claim.

A good example of an industry where B&M risk focus is essential is in power generation facilities. In recent years, insurance claims related to property and other economic losses in the power industry have skewed heavily toward events related to machinery breakdown. In fact, a major insurance brokerage estimates that as many as 67 percent of the insurance claims filed by the power industry were related to B&M risks [1]. Such data illustrates the potential impact of B&M risks, the undisputed need to better understand the root causes of such losses and how to more effectively manage them.

The sources of B&M risks in the power generation industry are numerous, complex and are being driven in part by the introduction of new technologies and materials, and the shift to renewable energy sources. These and other dynamics introduce new variables in the safety/risk equation, increasing the importance of training in the identification and amelioration of B&M-associated risks.

The power generation industry is not alone in facing new B&M risk issues as a result of rapidly changing industry technologies and demands.



The power generation industry is one example where B&M risk focus is essential to business operations.

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# 4. Reducing B&M risk: Likelihood and severity

Successfully mitigating B&M risks ultimately depends on a thorough analysis that addresses the two critical factors in risk mitigation: 1) the likelihood of harm occurring; and 2) the potential severity of the harm (see Table 1).

TABLE 1: RISK MITIGATION MATRIX

| | | POTENTIAL SEVERITY OF THE LOSS | | |
|---|---|---|---|---|
| | | Slightly Harmful 1 | Harmful 2 | Extremely Harmful 3 |
| LIKELIHOOD OF THE LOSS OCCURRING | Highly Unlikely to Occur 1 | Trivial 1 | Tolerable 2 | Moderate 3 |
| | Unlikely to Occur 2 | Tolerable 2 | Moderate 3 | Substantial 6 |
| | Likely to Occur 3 | Moderate 3 | Substantial 6 | Intolerable 9 |

A risk's rating is calculated by evaluating the likelihood of the risk or loss occuring against the potential severity if the loss were to occur.

This is Risk Management 101, but every party involved in B&M risk mitigation should keep these factors foremost in their minds. In fact, any plan or recommendation for addressing risk should be evaluated for its potential to reduce either the likelihood or severity of losses. Otherwise, such a plan or recommendation falls short of the goal of risk improvement.

In the B&M world, efforts to reduce the likelihood of harm are largely focused on ensuring that asset management and reliability (AM&R) programs addressing electrical, mechanical, and control & instrumentation (C&I) issues are being taken as far as can be economically justified.

Effective asset management is a "cradle-to-grave" concept that addresses machinery and equipment design, selection, installation, maintenance, testing and inspection, and end-of-life planning. Asset reliability, on the other hand, is evaluated in accordance with the specific hazards for a given occupancy and based on industry loss factors as well as the application of new risk-mitigation technologies and techniques, and other industry best practices.

The introduction of new technologies and tools is making significant contributions to the reduction of B&M-related risks in industrial settings. However, in addressing such risks, it is also important to focus primarily on those steps and actions that can be economically justified. Therefore, it is critical to continuously examine the basis for prioritizing one action over another in the context of both its impact and its economic cost.

# 5. Specific areas for risk reduction

## 5.1 Protection systems and devices

When a machinery breakdown event occurs, adequate protection mechanisms such as electrical protection, turbine overspeed protection and boiler controls should be in place to prevent such a situation from escalating. An assessment of the adequacy of protection features for critical machinery is therefore a key part of any B&M survey.

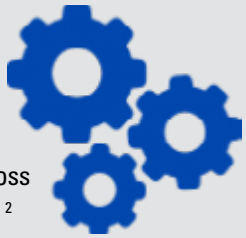
Routine testing of protection systems and features used in conjunction with critical machinery is an important step in mitigating the consequences of machine failures or breakdowns. Such testing should be conducted in accordance with established industry best practices and be further informed by actual experience in the facility. The testing frequency of a given protection system depends on the known level of reliability of the system or the device. Upgrading existing protection systems to incorporate new technologies is another way to help prevent risk escalation. For example, for many years, low-water level protection devices for boilers typically used floats as a critical feature to help prevent boiler failure. But, the floats were prone to sticking due to scale deposits on the boilers' interior walls, increasing the potential for explosions attributable to incidents of dry-firing. Today, modern level protection devices, such as those that employ self-monitoring with automatic routine testing (SMART) technology, are less prone to failure and can reduce the risks.

As previously noted, the choice between more frequent testing and the replacement of existing protection systems with new technology must also account for the investment required and the economic benefit. An experienced B&M risk consultant can help conduct a thorough assessment of the individual risk factors associated with current protection systems and advise on an approach that reduces risk while also being economically sound.

### Did you know?

Machinery and equipment breakdown incidents make up

**28%**



of losses across all industries. [2]

## 5.2 Post loss mitigation

In most B&M-related events, the impact of property damage is almost always exceeded by adverse consequences stemming from business interruption. Although the likelihood of an adverse event can be significantly reduced with effective AM&R programs, and the severity can be controlled by reliable protection features, history shows us that that exposure to significant losses still occur.

The post-loss consequential impact of an adverse event can be mitigated by ensuring that inventories of critical spare parts are adequate and readily available. At the same time, building cost-effective spare parts inventories is not always a simple exercise. If this goes wrong an operation can tie up millions of dollars in capital that may never be used, while neglecting more critical investments. Indeed, investments in spare parts inventories can often surpass the amounts required to implement more effective maintenance strategies.

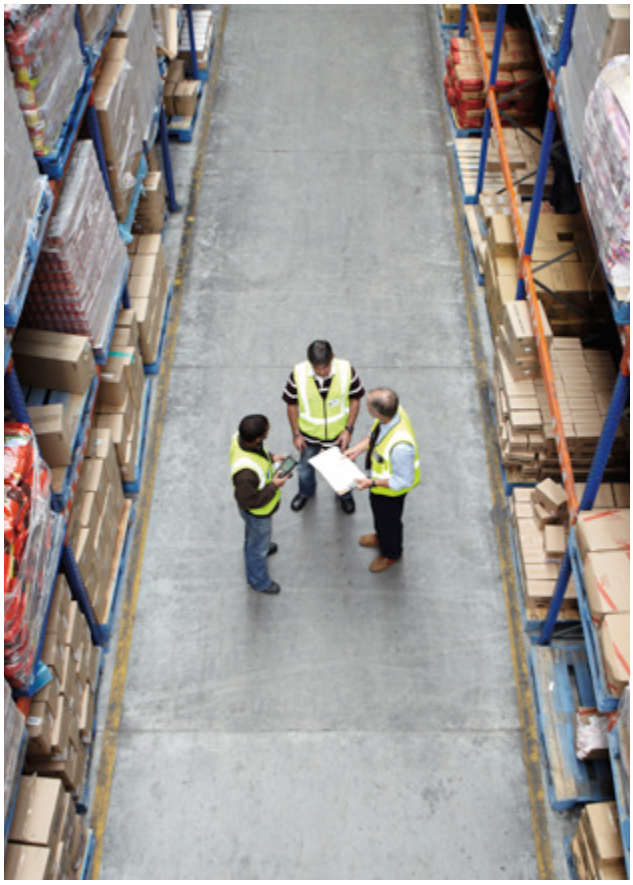
One way to address this challenge is to consider potential opportunities for working with other companies who have similar operations and equipment requirements to collectively pool essential spare parts. In some cases, partnering with third parties may even make the procurement of spare parts

and equipment requiring large capital investments (such as power plant generators) a viable option.

Once the decision is made to invest in an inventory of critical spare parts, it is also imperative to ensure that these parts are reliable and ready for use when needed. Sadly, many companies spend large sums of money on spare parts, place them in a warehouse or field location, and never consider their readiness and reliability until they are needed. Storage and handling procedures for spare parts should be implemented to ensure their long-term reliability and to help secure the value of the required investment.

Finally, it is important to develop workarounds or contingency plans to help mitigate the effects of foreseeable loss events in cases where spare parts are not available. However, such plans should be regularly evaluated by an independent third party to assess their validity and thoroughness, as well as their potential effectiveness and safety.

Spare part inventories and contingency planning are important steps that all facilities should consider to reduce the impact of loss events and help mitigate adverse, post-event consequences.



Storage and handling procedures for spare parts should be implemented to ensure their long-term reliability and securing of investment.

## 5.3 Risk management systems

Ultimately, the aspects of risk reductions previously discussed can only be successful in the long term if they are implemented within the context of sound risk management systems. Reliability programs and maintenance systems and procedures must be effective and resilient enough to support sustained improvements over time. Effective risk management can help ensure that testing is conducted as required, that the work necessary to address deficiencies is performed on a timely basis, and that checks are in place to provide adequate follow-up. In this way, effective risk management systems can help address not just the symptoms of risk but the systemic issues that produce that risk.

> "Effective risk management systems can address not just the symptoms of risk, but the systemic issues that produce that risk."

# 6. The importance of a B&M risk survey

Safety inspections of B&M equipment conducted by jurisdictional authorities are a fact of life for most industrial facilities. Most jurisdictional inspection requirements address the design and construction of boilers and other pressure retaining equipment, lifting equipment, electrical systems and hazardous chemical storage systems. Inspections also generally include checks for the mechanical integrity of B&M systems and equipment, using various visual and non-destructive testing methods to conduct such assessments.

However, the specific inspection requirements mandated under statutory inspection regulations vary from jurisdiction to jurisdiction, with each country having its own specific standards for the integrity and safety of B&M equipment. The Pressure Equipment Directive (2014/68/EU) in the European Union (EU) and ASME Boiler & Pressure Vessel Codes represent an important effort to harmonize such requirements. This being said, there are still differences between countries throughout the EU and around the world.

In addition, many specific inspection requirements have become less prescriptive in recent years, shifting instead to a risk-based approach for evaluating equipment integrity and safety. Furthermore, inspection requirements often do not define the nature or frequency of inspections. It remains a simple fact that most jurisdictional inspection requirements are reactive in nature, reflecting actual life safety experience; they are updated after the fact to address emerging trends in loss history (often, only after an increase in fatalities or injuries).



Pressure equipment on the EU market is subject to Pressure Equipment Directive 2014/68/EU, and represents an important effort to harmonize B&M requirements globally.

Compliance with applicable jurisdictional requirements typically requires meeting only the minimum safety and integrity thresholds. As a result, the majority of B&M equipment failures occur with equipment that is fully compliant with jurisdictional inspection requirements. Many such failures are attributable to design issues or operational factors that fall outside the scope of a mandated inspection.

A B&M survey can provide an important supplement to the findings of jurisdictionally mandated inspections. Conducted by an independent third party, a survey can affirm the findings of a facility inspection conducted under jurisdictional authority or assess whether issues identified in the inspection have been adequately addressed. However, a B&M survey also views equipment safety and integrity issues through a much wider lens, evaluating and quantifying issues such as machinery breakdown risks in a given facility, the extent of protections provided and whether operator training is sufficient.

As such, a B&M survey can provide a facilities operator with important insights into the actual risk profile of their operations. The objective, in-depth assessment generated from a B&M survey can identify critical risk areas that have gone undetected in mandated inspections. Furthermore, a B&M survey can provide evidence supporting the adoption of industry best practices for addressing and mitigating risks. These and other benefits make a B&M survey an essential tool in minimizing risk, increasing operational resilience, and supporting strong financial performance.

**GLOSSARY OF ACRONYMS**

B&M – Boiler & machinery
GRC – Global Risk Consultants
EMEA – Europe, the Middle East, and Africa
IRM – Institute of Risk Management
IOSH – Institute of Occupational Safety and Health
TAPPI – Technical Association of Pulp and Paper
NFPA– National Fire Protection Association
FMG – Factory Mutual Group
AM&R – Asset management and reliability
C&I – Control and instrumentation
SMART – Self monitoring with automatic routine testing
EU – European Union
ASME – American Society of Mechanical Engineers

**ENDNOTES**

[1] Marsh. "Global Loss Trends: Analyzing the Causes of Power Generation Claims." September 2016.

[2] FM Global. "FM Global to expand its boiler and machinery engineering staff by 40 percent, hiring 60+ new engineers to counter rising risk." FM Global Newsroom. 29 Apr. 2019.

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