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MARSH REPORT | September 2016

GLOBAL LOSS TRENDS: ANALYSING THE CAUSES OF POWER GENERATION CLAIMS

MARSH GUY CARPENTER MERCER OLIVER WYMAN MARSH & McLENNAN COMPANIES

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INTRODUCTION

There has not been a single year over the past decade in which power generation operators have not sustained a loss in excess of US$25 million; despite the many millions of dollars invested in risk management and operational safety.

To complicate matters, the causes of these losses have become increasingly varied. The technology involved in the industry is becoming ever more complex and inter-linked, while renewable energy, the changing fuel mix, life cycle upgrades, and older station cycling are all adding additional stress to the grid.

Using claims data from power accounts handled by both Bowring Marsh, Marsh's dedicated international placement division, and AIG, the largest power generation (re)insurer in the London market, this report provides information on the primary and secondary causes behind of some of the industry's largest and most complex post-millennium losses. Given the extent of the resources that have been combined to produce this report, we believe the losses contained within it are representative of the global industry as a whole.

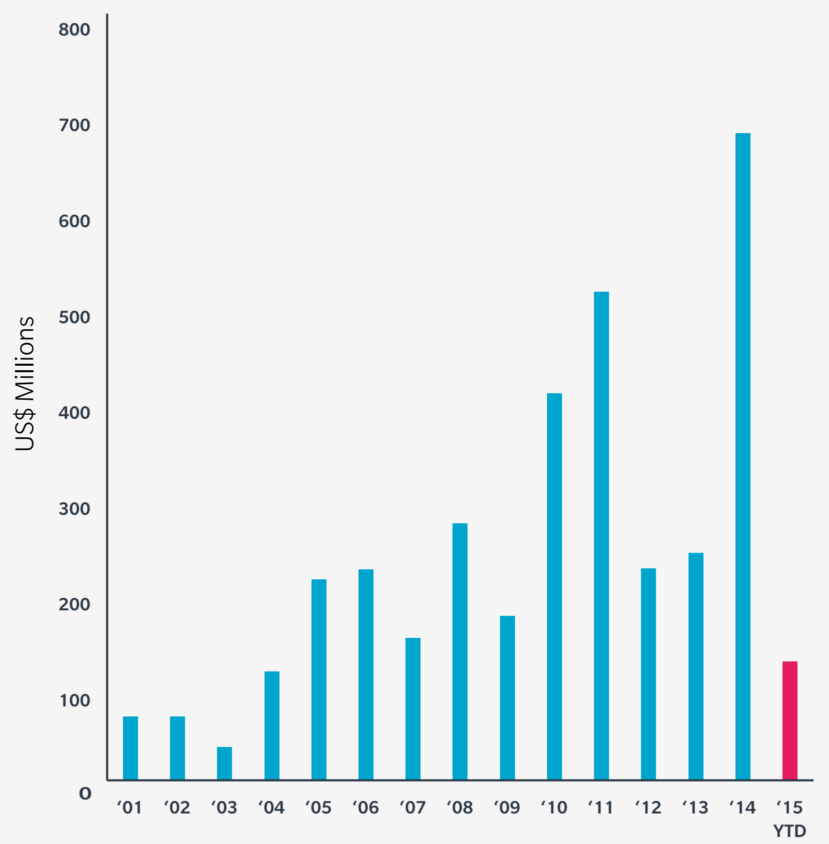
We therefore hope this report helps risk managers to identify the areas of greatest operational risk at their own facilities. This will, in turn stimulate discussions between them and their original equipment manufacturers (OEMs) in such a way that helps to improve the risk profiles of their organisations.

INSURANCE CLAIMS TRENDS IN THE POWER INDUSTRY

The insurance industry has paid out large sums for power losses stemming from machinery breakdown, fire, natural perils, and business interruption. As a consequence, the power generation industry is often perceived by insurers as being high risk. To evaluate whether this observation is accurate we need to review a history of some of the losses incurred by the insurers that provide coverage to the global power industry.

The graph below reflects the sum total of Bowring Marsh's London power claims valued in excess of US$2 million net of any self-insured retentions.

FIGURE 1 **Losses by Year 2001-2015**
Source: Bowring Marsh



While claims activity inevitably varies, there is an upward trend in the scale of individual power losses. For example, in 2001 the largest three claims were US$13 million, US$11 million, and US$7 million; more than 10 years on, in 2014, the scale of claims had risen dramatically to US$233 million, US$70 million, and US$55 million. Power generation losses are getting larger, reflecting raw material prices, the increasing complexity and price of equipment, the reduction of tolerances, and materials that are more difficult to work with.

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Common trends in equipment losses include:

BOILERS

Generally speaking, the most common types of boiler loss resulted from a problem with the quality and quantity of fuel used. Fuel oils can be contaminated with salt water, notably ballast, during loading or decanting or during sea-faring transport. Impurities can also contaminate the fuel oil during road/rail transport, or via non-dedicated pipelines. Ensuring correct fuel specification and quality management is vital and can be particularly crucial in the waste-to-energy sector, where insufficient sorting of waste can lead to pressurised or volatile items being improperly added to the boiler's fuel feed.

The improper burning and/or subsequent build-up of fuel can also lead to serious consequences. Many claims have arisen as a result of some form of failure due to large quantities of unburnt fuel igniting suddenly. Adherence to OEM-recommended operating and maintenance practice is often a condition of claims coverage or, in some cases, even a warranty that could affect the insurance coverage. Losses have resulted from poor maintenance practices or from poor operational procedures, such as inadequate testing of safety systems.

GAS TURBINE COMPRESSORS

The large number of losses in the compressor section of gas turbines reflects their obvious vulnerabilities. Losses arise as a result of the atmospheric conditions they operate in, making adequate filtration vital, particularly in areas of high salinity, dusty environments, or heavy industrial areas. Air filtration systems need to be individually adapted to suit the conditions at any particular site. Inadequate filtration has repeatedly led to blade damage from either incrustation or corrosion. Most losses unrelated to filtration are as a direct result of blade failures, for reasons that are commonly found in turbine losses (see below).

TURBINES

The turbines being installed in many of today's power plants are complex machines. Whether they are wind, water, steam, or gas turbines, a large number of historic machinery breakdown losses occurred within the turbine. Particular vulnerabilities include oxidation, corrosion, high/low cycle fatigue, thermal mechanical fatigue, rubbing/wearing, and creep fatigue. These risks are the subject of extensive documentation and have featured largely in previous Marsh publications. Other common causes of failure in large rotating equipment, such as turbines and gas turbines compressors, are due to foreign object damage (FOD). This is where materials have been left inside the machine during maintenance or due to domestic object damage, sometimes mistaken as FOD, resulting in material being released within the machine and passing through causing extensive down-stream damage.

A gas turbine's lifespan and operating performance, especially hot gas path elements, are particularly vulnerable to impurities in fuel and contaminants entering the system, and from contaminated air passing through the compressor and turbine sections. This is especially true in thermal plants, where losses of this type are common and should be carefully monitored. Trace metals found in hydrocarbon fuels, notably lead, vanadium, sodium, and potassium also need to be observed with caution. Similarly, the quality of steam supply to a steam turbine is critical to operations, and contaminated steam, usually as a result of condenser leaks, can rapidly result in corrosion and, ultimately, failure of the steam turbine.

SPOTLIGHT

EQUIPMENT LOSSES RESULTING IN LARGER CLAIMS

Losses in the power generation sector are undoubtedly getting larger, reflecting fluctuating raw material prices, the increasing complexity and price of equipment, the reduction of tolerances (requiring greater engineering complexity and accuracy), and materials that are more difficult, and therefore more expensive, to work with (such as single-crystal blades). In short, the more complicated the machine is, the higher the cost and the longer the time required to repair or replace it, resulting in a longer period of business interruption. Aging assets also contribute to the increasing frequency of losses.

Over the past decade, the most frequent type of damage to equipment at power generation facilities was to gas turbines, steam turbines, generators, and transformers. Losses reflect a range of different causes, with some clear patterns emerging, including machinery breakdown, human error, design issues, and aging infrastructure. These losses are consistent with historical loss trends within the industry. Engineering changes in steam turbines and an increase in the size and use of more powerful gas turbines have facilitated the continuation of this trend.

Given the considerable lead time for replacement parts, interruption to the business and disruption to supply is commonplace in all types of turbine losses. Due to the long lead times of specialist components, obtaining spare parts may prove difficult. First- and second-generation wind turbines, for example, often use parts that are obsolete and can therefore only be obtained from decommissioned machinery. Considering the age of the current fleet (plants in Europe and the US are often at least 40 years old), this is clearly a serious issue in the event of a loss.

GENERATORS

Generator failures often arise from short-circuits, with consequent damage to rotors and stator bars and even core damage. Other causes can include transmission system issues, lack of balance in electrical/magnetic currents, and improper frequency. Short-circuits can occur as a result of inappropriate closing of the generator breaker to earth, contamination of the insulation, vibration and fretting causing insulation to be damaged, or due to general age and condition, such as high levels of electrical discharge. Losses have also occurred when the field switch has failed to operate and the generator has become the prime mover and motored the normal drive. Protective relays have helped reduce this issue, preventing the generator from being motorised by the grid instead of providing electricity to the grid; however, instances do still occur. There have also been several losses where seals have been damaged leading to hydrogen (used to cool the generator) leaking, with a consequential fire that is difficult to extinguish.

TRANSFORMERS

The leading cause of losses in transformers results from insulation failure, which is due to defective windings or deterioration (often age-related). However, the most common cause is due to the deterioration in quality of the winding and insulation oil.

Other causes include external events – either direct impact or by surges such as grid problems, lightning strikes, or wild-fire. Generator step-up transformers tend to result in more expensive incidents, while substation losses are the most common.

Transformers are continually subject to chemical, electromagnetic, mechanical, thermal, and electrical stresses while under load conditions. One of the most common causes of insulation failure in recent years is cupric sulphur deposition on the copper winding. This leads to damage to the paper insulation, which can escalate and result in a breakdown to earth, usually in the transformer's core.

Internal faults are often catastrophic and can lead to the tank rupturing and a consequential fire. Transformer oil analysis, including sulphur content, is a vital part of monitoring systems and the results of the testing need to be acted on to be effective. Loss reports frequently show that tests undertaken prior to a loss indicate deteriorating conditions, but no or inadequate action was taken.

Other common causes of transformer failure are due to bushing and even cable termination failures, which can result in significant damage and cause business interruption due to the lead time of parts.

SPOTLIGHT

GAS TURBINE COMPRESSOR FAILURE

A gas turbine suffered mechanical breakdown with the failure and liberation of a compressor blade, which cascaded down the flow path and damaged other vanes and blades.

The unit required the replacement of its compressor rotor and stator components from the OEM parts depot, with an outage time of more than 10 weeks. The unit operated in an aggressive environment with a corrosive atmosphere, and there was insufficient filtration of the air, inconsistent water wash, a lack of regular borescope inspections, and a lack of compliance of OEM service bulletins to address known problems.

Since gas turbines move large volumes of air, it is essential that the air quality be maintained to keep out dirt and corrosive elements. In areas of high corrosion or dirt, extra attention needs to be paid to the air inlet system. Inspections such as an annual borescope should be performed by trained personnel in accordance to OEM guidelines. All OEM service bulletins and operating experience learned from user groups should be reviewed and formally circulated by engineering.

LOSS FIGURES AND LOSS SPLITS

Using the combined claims expertise of Marsh and AIG, Bowring Marsh has compiled a list of losses. The sub-cause of these losses will be of considerable interest to risk managers and operators. This is because, while an explosion or similar event might result in a loss, from a claims perspective, it is the actual cause that needs to be managed and determined to ensure it is less likely to occur in the future.

We have identified 48 losses on our database where both the loss category and the equipment that failed have been determined (see figures 2 and 3). What is crucial about these particular losses, is the fact that in each case the sub-cause was able to be definitively identified. While categories of loss such as machinery breakdown are broad and can cover a multitude of different machinery types, ages, and purpose, the sub-causes point to what is truly of interest to risk managers and operators: what actually went wrong. It is only by identifying the actual details of what occurred that we can help risk managers to build an accurate picture of the loss types that affect the industry. Each of the 48 losses highlights a key area where a failure resulted in a multi-million US dollar loss to a power station. Investigating these losses in greater detail and knowing what failed and why is part of the first step in avoiding a repeat of these events.

FIGURE 2 Loss Category by Value 2001-2015
Source: Bowring Marsh

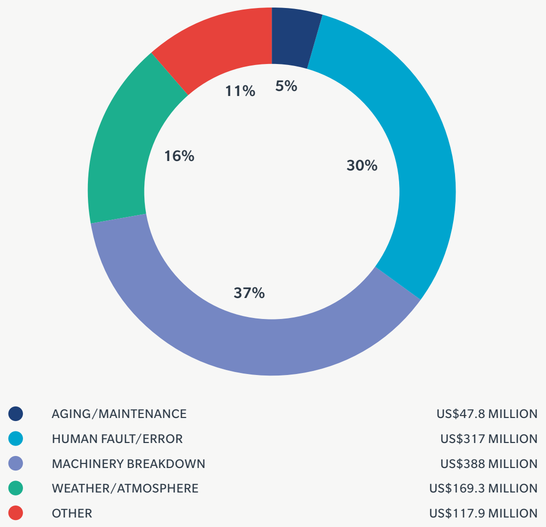
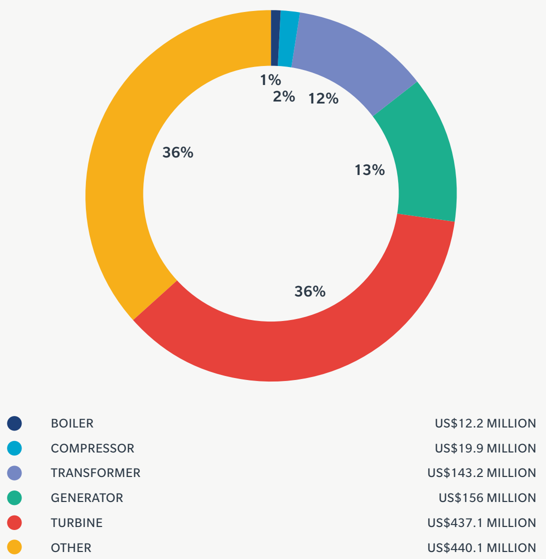


FIGURE 3 Equipment Loss by Value 2001-2015
Source: Bowring Marsh



MACHINERY BREAKDOWN

Machinery breakdown may be defined under standard insurance policy cover as a sudden and unforeseen physical loss or damage.

EQUIPMENT DAMAGED	YEAR	MAIN CAUSE	SUB-CAUSE	NET
GAS TURBINE	2001	DAMAGE TO COMBUSTOR AND HIGH PRESSURE COMPRESSOR TURBINE BLADES	DELAMINATION OF HEAT SHIELD TILES	US$15 MILLION
COMPRESSOR	2004	DAMAGE TO BLADES AND VANES	SURGE IN COMPRESSOR	US$8.4 MILLION
STEAM TURBINE	2005	FIRE DAMAGE TO STEAM TURBINE	BLADE LIBERATION, LUBE OIL IGNITION	US$81 MILLION
SWITCH ROOM BUILDING	2005	FIRE DAMAGE TO SWITCH ROOM BUILDING	ELECTRICAL FAULT	US$12.9 MILLION
FAILURE OF MAIN GENERATOR STEP UP TRANSFORMER	2006	DAMAGE TO HIGH-PRESSURE/LOW-PRESSURE COIL	TURN TO TURN SHORT CIRCUIT	US$10.8 MILLION
STEAM TURBINE	2008	LOW PRESSURE TURBINE BLADE LIBERATION	STRESS CORROSION CRACKING	US$78 MILLION
STEAM TURBINE	2008	DAMAGE TO HIGH-PRESSURE/LOW-PRESSURE ROTORS	TUBE FAILURE IN HEAT EXCHANGER	US$12.5 MILLION
TURBINE COMPRESSOR	2008	VANE LIBERATION	FAILURE OF LOCATING TAB ON VANE	US$5.5 MILLION
GAS TURBINE	2009	HIGH PRESSURE COMPRESSOR BLADE DAMAGE	HIGH CYCLE FATIGUE	US$39.5 MILLION
GENERATOR	2010	STATOR BAR FAILURE	VIBRATION	US$15.4 MILLION
TRANSFORMER	2010	DAMAGE TO WINDINGS	HIGH VOLTAGE BUSHING FAULT	US$14 MILLION
GENERATOR	2010	DAMAGE TO GENERATOR STATOR AND ROTOR	LATENT TRANSFORMER HIGH VOLTAGE COIL FAULT	US$5.5 MILLION
GAS TURBINE	2011	DAMAGE TO COMBUSTOR AND HIGH PRESSURE COMPRESSOR TURBINE BLADES	DELAMINATION OF HEAT SHIELD TILES	US$28.6 MILLION
STEAM TURBINE	2011	FOREIGN OBJECT DAMAGE TO BLADES	FAILURE OF STEAM VALVES	US$14.5 MILLION
GAS TURBINE	2011	DAMAGE TO COMPRESSOR BLADES/VANES AND TURBINE BLADES	FRACTURE OF COMPRESSOR VANE CARRIER KEY	US$10.1 MILLION
GENERATOR	2011	DAMAGE TO ROTOR	FAILED CIRCUIT BREAKER	US$8 MILLION
TRANSFORMER	2013	FIRE DAMAGED TRANSFORMER	INTERNAL FAILURE OF LOW VOLTAGE BUSHING	US$7.5 MILLION
STEAM TURBINE	2013	COAL DAMAGE TO HIGH PRESSURE AND LOW PRESSURE TURBINES AND GENERATOR	OVERSPEED DUE TO STEAM VALVE FAILURE	US$10.4 MILLION
GAS TURBINE	2014	GAS DAMAGE TO LOW PRESSURE TURBINE	STRESS RUPTURE OF BLADES	US$5.6 MILLION
STEAM TURBINE	2014	COAL DAMAGE TO BLADES AND BEARINGS	LUBE OIL FAILURE	US$5 MILLION

HUMAN ERROR

Human error accounted for 30% of the 48 losses we examined. Human error is a non-automated action/inaction that was unintended, or a breach of rules that results in improper system operation. Given the complexity of today's power generation systems, both automated and human-operated, it is inevitable that human error/misunderstanding plays a significant role in power generation losses.

EQUIPMENT DAMAGED	YEAR	MAIN CAUSE	SUB-CAUSE	NET
GENERATOR AND PLANT INSTALLATIONS	2002	FIRE	OPERATOR ERROR	US$12.6 MILLION
TRANSFORMER	2004	FIRE	WELDING REPAIR IGNITED INSULATING OIL	US$7.4 MILLION
GAS TURBINE	2006	DAMAGE TO BLADES AND VANES	OVERSPEED TEST	US$7.5 MILLION
GENERATOR	2008	EARTH FAULT	UNIT MISALIGNMENT BY OEM	US$13.4 MILLION
BOILER	2008	FAILURE OF BOILER TUBES	VIBRATION DURING TRANSIT	US$6.9 MILLION
GAS TURBINE	2009	DAMAGE TO COMBUSTOR HUB	FAILURE OF PREVIOUS REPAIR TO FUEL NOZZLE	US$5.9 MILLION
COLLAPSE OF HEADRACE TUNNEL	2010	TUNNEL COLLAPSE DUE TO EROSION OF TUNNEL LINING	DEFECTIVE WORKMANSHIP	US$124.9 MILLION
STEAM TURBINE	2011	OIL SPILLAGE FROM JACKING TUBES AND SUBSEQUENT FIRE	DEFICIENT INSTALLATION CAUSED VIBRATION	US$600,000
STEAM TURBINE	2012	LOW PRESSURE TURBINE BLADE LIBERATION	OPERATOR ERROR	US$30.4 MILLION
STORES AND CONVEYORS	2012	IGNITION OF MATERIALS IN THE HAMMER MILL	SMOULDERING MATERIALS DELIVERED	US$19.9 MILLION
FLUE-GAS DE-SULPHERISATION ABSORBER	2014	FIRE	WORKMANSHIP	US$74 MILLION
GENERATOR AND TRANSFORMER	2014	FIRE	OPERATOR ERROR	US$13.5 MILLION

Human error takes many forms. It may consist of simply not following correct procedures. Procedures could be faulty, erroneously amended, or lack specificity, completeness, or information that was not properly considered or understood to be part of the risk.

Other causal factors could include poor training and work practices, problems in clearing and tagging equipment for maintenance, shortcomings in equipment repair, or lack of inspection or sufficient issue detection.

DESIGN FAILURE

With tolerances in microns, internal temperatures higher than an active volcano, and atmospheric pressure in excess of 40 bar, the inside of today's modern power generation machinery requires flawless design and assembly.

EQUIPMENT DAMAGED	YEAR	MAIN CAUSE	SUB-CAUSE	NET
GAS TURBINE	2008	DAMAGE TO COMPRESSOR	HIGH CYCLE FATIGUE	US$26.4 MILLION
STEAM TURBINE	2008	FAILURE OF HIGH PRESSURE TURBINE THRUST BEARING	DESIGN SPECIFICATIONS	US$25.1 MILLION
STEAM TURBINE	2008	FAILURE OF HIGH PRESSURE TURBINE THRUST BEARING	DESIGN SPECIFICATIONS	US$22.9 MILLION
TRANSFORMER FAILURE	2008	COLLAPSE OF LOW VOLTAGE BUS BAR FRAME	DEFECTIVE DESIGN	US$18.2 MILLION
TRANSFORMER FAILURE	2008	WINDING FAILURE	DESIGN/OVERHEATING/OIL INSULATION	US$11.6 MILLION
TRANSFORMER FAILURE	2009	WINDING FAILURE	DESIGN/OVERHEATING/OIL INSULATION	US$29.8 MILLION
SMOOTHING REACTOR	2012	DAMAGE TO WINDINGS	COOLING DESIGN ISSUE	US$34.4 MILLION

Design failure can take many different forms, including cracking, creep, deformation, wear and tear, and corrosion. In excessive cases, it may also include melting. With power losses, it is often the ensuing damage that is most serious. For example, if a single turbine blade is damaged during operation, it is the impact on blades further downstream that causes far more problems and significantly increases the cost of physical repair and business interruption coverage. Likewise, if a transformer insulation fails, it is the arcing and subsequent fire/explosion that will impact operators and insurers, as well as being a serious safety issue with the potential to cause fatalities.

Much has been written about the need for long-term testing of machinery in actual running conditions. Given the complications and demands of today's designs, there can be no substitute for equipment that has been fully tested and validated in operating conditions. Unfortunately, pressure on the power industry is so high in terms of efficiency demands that small margins can lead to immense variation in profitability. The need to balance cutting-edge design with proper testing is a difficult balance for OEMs and operators, as well as for those seeking to insure them.

AGING/MAINTENANCE

It is inevitable that all machine parts will eventually fail due to age. Ideally, parts are replaced according to the agreed OEM guidelines and conditions to ensure maximum use.

EQUIPMENT DAMAGED	YEAR	MAIN CAUSE	SUB-CAUSE	NET
TURBINE	2010	DIRECT CURRENT POWER FAILURE	AGE DETERIORATION	US$10.9 MILLION
TRANSFORMER	2010	FAILURE OF TAP CHANGER	AGE DETERIORATION	US$8.6 MILLION
GENERATOR	2010	STATOR GROUND FAULT	AGE DETERIORATION	US$6 MILLION
TRANSFORMER	2011	LOOSE CONNECTION LEADS LEAD TO ARCING AND SUBSEQUENT FIRE	AGE DETERIORATION/ LOOSE BLOCKING	US$22.3 MILLION

Insurers are understandably very focused on ensuring that insurance policies do not take the place of maintenance. A full maintenance schedule is vital, not only in theory but also in practice. While this may seem an obvious point, the fact is that such failures continue to occur on a regular basis. Given the increasing costs of replacement parts and the desire to stretch out the use of parts as long as possible, such adherence has been, and continues to be, problematic.

The UK's power generation sector demonstrates the vulnerability in supply that comes where aging plants are finally closed. For example, the closure of much of the UK's coal-fired plants has come about due to aging equipment being unable to meet the environmental standards required today, and this is now also affecting the older gas turbine plants that cannot meet current emissions standards. The announcement of the closures in 2015 was quickly followed by assurances that supplies would not be affected over the peak winter period following public concern. It has been some 40 years since the UK last built a coal-fired plant, yet such plants contributed 41% of UK electricity generation in 2013.

WEATHER/ATMOSPHERIC

Weather conditions such as wind and ice storms are easily identified. Atmospheric conditions arising from high natural salinity or contaminants arising from land reclamation can cause significant issues with filtration systems and corrosion. Significant losses have occurred in the Middle East, particularly on construction sites, due to flash flooding.

EQUIPMENT DAMAGED	YEAR	MAIN CAUSE	SUB-CAUSE	NET
STEAM TURBINE	2002	DAMAGE TO ROTOR	INGRESS OF WATER TO CONTROL CABLE	US$7.2 MILLION
POWER STATION	2010	FLOOD	WEATHER	US$31.4 MILLION
TRANSFORMER	2010	FIRE FOLLOWING INSULATION FAILURE	MOISTURE INGRESS FOLLOWING HEAVY RAIN	US$4.1 MILLION
TRANSFORMER	2011	DAMAGE TO HIGH VOLTAGE COIL	LIGHTNING	US$2.2 MILLION
GAS SUPPLY INSTALLATIONS	2012	WINDSTORM	WEATHER	US$124.4 MILLION

SPOTLIGHT

OVERSPEED EVENT

A 100-MW steam turbine generator suffered a severe overspeed event. The machine accelerated from 3,600 rpm to 6,000 rpm within 30 seconds, resulting in the complete destruction of the turbine and the generator. Solid steel parts of the machine were ripped apart by the centrifugal forces and spread across the turbine deck.

The turbine tripped due to an unknown condition within the hydraulic system, and the emergency stop (throttle trip) and governor valves did not close completely. The emergency stop valve is designed to close 100% but, in this case, remained open by less than one millimetre due to binding in the valve shaft.

One of the governor valves (not required to close tightly) also jammed due to valve stem issues. When the generator breaker opened, the small amount of steam was enough to overspeed the turbine.

Hydrogen gas leaked from the generator and accumulated within the building until it exploded and knocked the building wall onto the three transformers located beside the station, which were then destroyed in a fire. The lubrication oil from the turbine was ignited by this fire through openings in the wall, causing damage around the turbine generator and to balance of plant components.

Eventually, operators were able to shut down the lubrication oil pumps, but extensive firefighting was required to extinguish the fire. It was later learned that the valves had a history of being "sticky" and operations had a work around for this issue. Please see lessons learned on page 12.

RISK QUALITY AND INSURANCE WITHIN THE POWER GENERATION SECTOR

AN ENGINEERING INSIGHT

Due to the increasingly complex nature of risks presented by power generation assets, operators engage specialised risk engineers to make assessments on the quality and quantity of insured risks, and to determine a risk category for each plant. Risk analysis measures the amount of potential loss and, more importantly, the elements of a system that contribute to a loss.

In order to understand a risk, whether it's for insurance or risk management purposes, one normally needs to know the nature of the plant (that is, the inherent hazard) and the estimated maximum loss(es).

The likelihood and magnitude of an incident resulting in an insured loss depends to a large extent on the prevention (for example, machinery safety features) and mitigation (for example, fire protection) features of the risk, or, in other words, its risk quality. Risk ranking systems typically evaluate an operator's nominated assets across several topics against a defined set of criteria and, therefore, provide a valuable insight into the risk quality. In the power generation sector, topics are generally grouped under the three following categories: hardware, management systems, and emergency control.

Underwriters and risk engineers alike are generally of the opinion that sites with a higher risk ranking are less likely to produce major losses, as history would suggest that sites with a higher risk ranking (that is, better risk quality) have more favourable loss histories, both in frequency and magnitude.

Risk ranking categories generally reflect the features considered to be important from an underwriting perspective, and have the potential to reduce loss frequency and magnitude, such as machinery safety features. An example of the output from a risk ranking exercise is shown on the next page, which provides results for various topics as well as the consolidated overall scores.

This systematic risk ranking not only provides a valuable tool used in the underwriting process, it is also used by risk engineers and operators to understand deficiencies and improvement opportunities, and, therefore, where to focus risk management attention to prioritise expenditure. Recently, a high concentration of large losses within the global power industry has led to tightening of risk engineering requirements. By understanding their risk quality, power organisations have the opportunity to better identify and manage the risks, potentially preventing and mitigating future accidents and incidents.

SPOTLIGHT

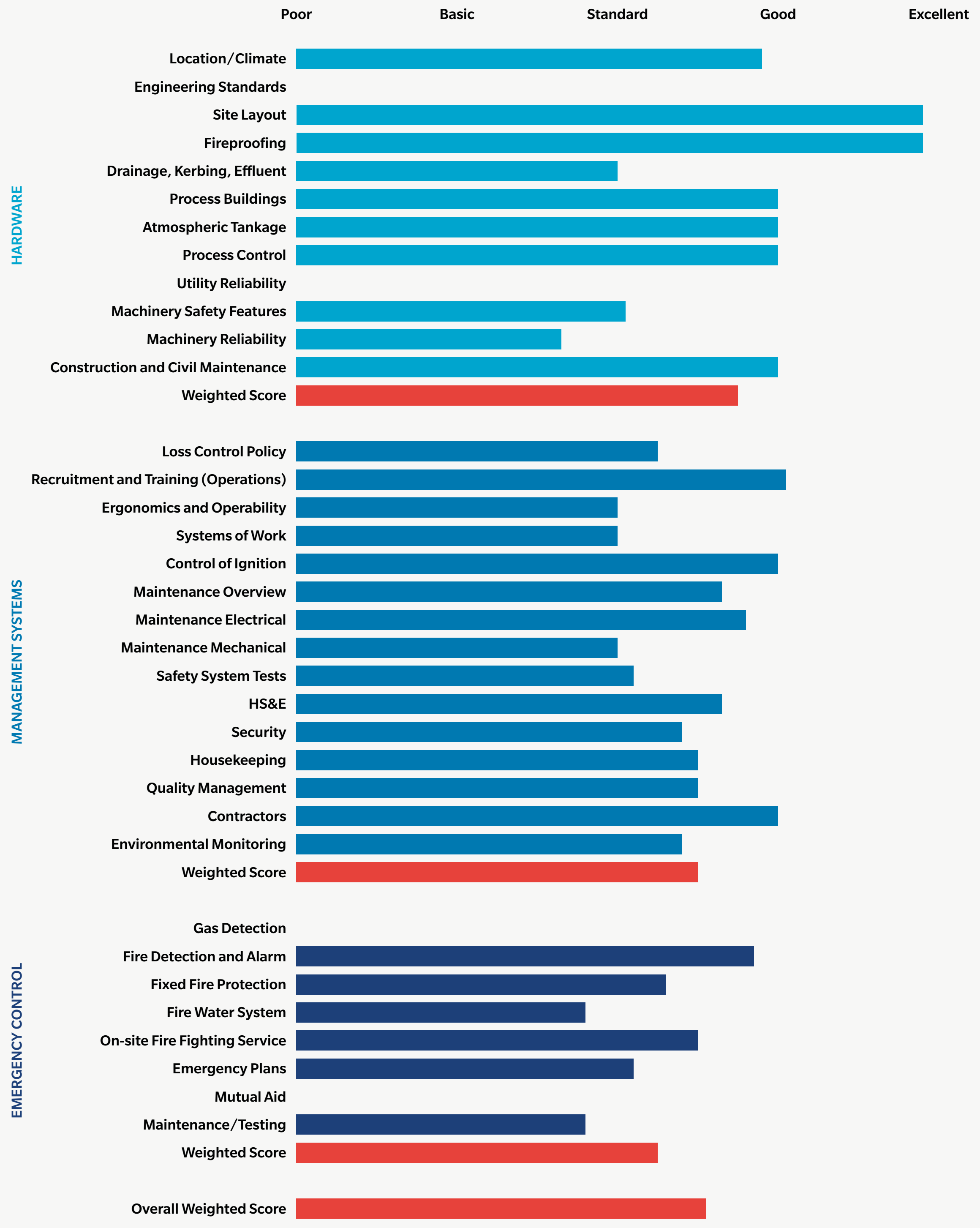
LESSONS LEARNED

- Steam turbine generators should be adequately protected with automatic sprinklers, in accordance with industry standards.
- Emergency stop valves should be stroke tested on a weekly basis, in accordance to OEM guidelines.
- Emergency stop valves and governor valves should be dismantled and inspected on a regular basis (typically three to five years), including tightness checks.
- Sticking valves should not be tolerated.
- Non-conformance of protective and control devices should not be tolerated.
- Overspeed protective schemes should be tested annually, in accordance with OEM guidelines.
- Sequential tripping schemes should not open the generator breaker until it can be confirmed that the steam supply has been completely isolated.

While the risk of overspeed failure is very low, operators should still take all reasonable precautions to prevent this as part of their normal practices.

FIGURE 6 Risk Ranking Scores

Source: Marsh's Global Energy and Power Engineering Practice



CONCLUSION

The causes and sub-causes of power losses have been increasingly varied in recent years, as the technology involved in the industry has become ever more complex and inter-linked. By providing a breakdown of major losses and their causes and sub-causes and exploring these, this document should provide greater clarity for risk managers as to what actually went wrong in many of these instances, so that they may take actions to mitigate the risk of loss at their own facilities.

Loss prevention is vital for ensuring the safety of employees, plant reputation, operating efficiency, and reductions in premium rates. The instances provided in this document should help educate operators about what has gone wrong in the past, so that they may work to ensure that similar incidents can be avoided in the future.

Notes

About Marsh

Marsh is a global leader in insurance broking and risk management. We help clients succeed by defining, designing, and delivering innovative industry-specific solutions that help them effectively manage risk. Marsh's approximately 27,000 colleagues work together to serve clients in more than 130 countries. Marsh is a wholly owned subsidiary of Marsh & McLennan Companies (NYSE: MMC), a global team of professional services companies offering clients advice and solutions in the areas of risk, strategy, and people. With 57,000 employees worldwide and annual revenue exceeding $13 billion, Marsh & McLennan Companies is also the parent company of Guy Carpenter, a global leader in providing risk and reinsurance intermediary services; Mercer, a global leader in talent, health, retirement, and investment consulting; and Oliver Wyman, a global leader in management consulting. Follow Marsh on Twitter @MarshGlobal.

Marsh's Claims Practice

At Marsh, we are best positioned to assist you by using our expertise, market knowledge, and relationships to develop a transparent claims resolution strategy. Our aim is to make sure there are no surprises and that your claim is settled in the optimum time, meeting your expectations. Our Claims Practice offers a range of services that go beyond claims handling, in order to help you reduce costs and improve efficiency. Each of our clients expects to receive a high-quality claims service from their insurer or broker. We believe that, through our range of claims services, we are excellently placed to provide skills and resource to meet your claims challenge.

About Bowring Marsh

Bowring Marsh is the dedicated, specialist international placement broker for Marsh. Working seamlessly with Marsh, Bowring Marsh provides you with risk transfer solutions, benchmarking, and claims advocacy wherever you are in the world through its global insurance placement network of 11 offices in the United Kingdom, Ireland, Continental Europe, Asia, the Middle East, Latin America, and Bermuda.

With more than 300 insurance brokers located across all the major international insurance hubs, Bowring Marsh provides international placement options that suit your business risk and exposures. We use our comprehensive portfolio experience, our in-depth knowledge of your risks, our ability to have face-to-face negotiations with decision makers, and our industry knowledge to innovate, customise, design, and place your insurance programmes with international insurers.

For more information, contact the Bowring Marsh colleagues below or visit our website at: www.marsh.co.uk.

SIMON HOWELL

Head of Power and Utilities
simon.m.howell@marsh.com
+44 20 7357 1864

NIGEL WARD

Marsh Global Claims Practice
nigel.ward@marsh.com
+44 20 7357 5062

BERMUDA

THOMAS CECHINI

thomas.p.cechini@marsh.com
+1 441 299 8848

DUBAI

MARK HILES

mark.hiles@marsh.com
+971 4 508 0486

LONDON

PAUL TAYLOR

paul.x.taylor@marsh.com
+44 20 7357 1034

MADRID

MIGUEL MARTINEZ

miguel.martinezpaniagua@marsh.com
+34 91 456 94 48

MIAMI

ENRIQUE MARRON

enrique.marron@marsh.com
+1 305 341 5094

SÃO PAULO

PAULA LOPES

paula.lopes@marsh.com
+55 11 3741 6390

SINGAPORE

STEVE HUTCHINSON

steve.hutchinson@marsh.com
+65 6922 8535

ZÜRICH

DARRYL KAUFMANN

darryl.kaufmann@marsh.com
+41 44 285 9320