Lessons Learned Database
Individual Incident Summary Report

IChemE
Safety & Loss Prevention
Special Interest Group

Incident Title	**Turbo-generator Disintegration**	
Incident Type	Overspeed	
Date	10th November 2007	
Country	USA	
Location	Springfield, IL	
Fatalities	**Injuries**	**Cost**
0	0	US$ 45 m (2012) – Ref. 2

Incident Description

Credit: CWLP/Texas A&M University

A 1968 vintage 100 MW_e steam turbine/generator tripped due to an unknown hydraulic control oil system failure. Within 30 seconds of the generator circuit breaker opening, the turbine accelerated from 3600 rpm to an estimated 6000 rpm (overspeed condition), resulting in catastrophic failure of multiple components of the turbine. Seal and bearing lube oil were released under pressure as the emergency battery-powered lube-oil pumps continued operating. The leaking lube-oil ignited, causing an intense fire around and below the stricken machine. The exciter and bearings were ripped from their mountings, causing total destruction of the generator. The generator shell was punctured, releasing hydrogen coolant which accumulated in the roof space of the turbine hall before exploding a few seconds later. The blast blew out ~ 30% of the turbine hall exterior block wall. Falling masonry damaged 3 outdoor transformers, rupturing associated oil coolers and initiating an oil fire. Repair and re-commissioning of the damaged machine took ~ 17 months.

Fortunately, the incident occurred on a Saturday evening with few employees on site. On a weekday, 14 people would have been in imminent danger as they normally work in a nearby electrical workshop where a wall collapsed.

Incident Analysis

Basic cause of turbo-generator set disintegration was turbine overspeed (this also initiated an accumulated hydrogen explosion and lubricating oil fire in the turbine hall, and an outdoor transformer insulating oil fire).

Critical factors included: 1) The steam turbine trip and throttle (T&T) and governor valves failed to close fully when the generator breaker opened (caused the turbine to accelerate), 2) Gaseous hydrogen accumulated in the turbine hall roof space (increased explosion severity), 3) Falling masonry damaged external transformers (initiating a transformer insulating oil fire).

Root causes included: 1) Inadequate preventative maintenance (T&T valves had a history of binding due to excessive stem oxidation [“blue blush”] and governor valves had a history of jamming due to excessive stem wear [“stepping”]), 2) Normalisation of deviance (operators used hydraulic jacks to dislodge sticking valves during startup), 3) Inadequate testing of safety-critical equipment (overspeed protection system, T&T and governor valves).

Lessons Learned

1) Trip and throttle (T&T) valve stems should be exercised regularly in accordance with original manufacturer guidelines (e.g. weekly).
2) Steam turbine overspeed protection systems should be tested regularly in accordance with original manufacturer guidelines (e.g. annually).
3) T&T valves and governor valves should be dismantled, inspected and leak tested regularly (e.g. 3 – 5 year intervals).
4) T&T valve and governor valve trims should be designed with appropriate metallurgy/coating to mitigate the risk of “blue blush” and “stepping” and with appropriate geometry and clearances to minimise buildup of fouling deposits.
5) Deviations from proper operation of safety-critical equipment should not be tolerated (e.g. eliminate use of hydraulic jacks to free sticking valves).
6) Steam turbine/generators should have automatic fire suppression systems.

More Information

1) “Unit 31 Generator Failure Report”, CWLP Generation Division (2008).
2) “The Impact of Large Losses in the Global Power Industry”, Marsh Risk Management Research (2012).

Industry Sector	Process Type	Incident Type
Power Generation	Coal-Fired	Overspeed
Equipment Category	**Equipment Class**	**Equipment Type**
Rotating	Steam Turbine	Condensing

Peter Marsh
Director – XBP Refining Consultants Ltd.