

Certainty in an Uncertain World

# Application of General and Specialist Engineering Knowledge

**Root Cause Analysis** 

#### **BLADE FAILURE**

Wolverhampton – UK, 2011



## The Plant



- Wolverhampton awarded 27 year contract for the safe disposal of the areas municipal waste, exceeding 100 000 tonnes each year.
- The plant environmentally-friendly process which produces electricity from household and commercial waste



# Waste to Energy

- Incinerating paper wastes
  9,824 kwh per ton!
- Incinerating soda bottles wastes 7,216 kwh per ton!
- Incinerating aluminium cans wastes 62,512 kwh per ton!





#### Turbine















### Damage







# Testing







# Testing





### **Testing Results**

- Blade fragments show signs of metal fatigue, caused by repeat loading of the blades beyond their tolerance.
  - The metal fatigue caused cracks that initiated in the blade structure and propagated over time until eventually a catastrophic failure occurred.
  - The metal fatigue in the blades was caused by erosion of the surface which was caused by impact with loose particles while the blades were rotating at very high velocities.
  - Particles of silicon (sand), metal (from blade fragments) and paint were found embedded in the irregular surface of the eroded blades.



#### System Configuration







#### Steam Pumps





#### **Steam Inlet Screen**





#### **Boiler Water Feed Pump Filter**





	Sample Number and Location	Description	SEM EDX Identification	Most Likely Source	
	1) Steam input screen	Flaking deposits	Mostly iron oxide	Steel corrosion	
	2) Steam control valve	Film on surfaces and flakes at edges	-Some lead particles (200x75µm)	-Lead/copper particles could be wear particles from a bearing or gasket material.	
			-Some copper particles with lead (50x40µm)		
			-Silica and oxygen	-The silica and oxygen particles are likely to be from steam water contamination	
			(some 140x140μm, most smaller 50x50μm)		
			-Some ferrous particles (220x70μm)	-Ferrous particles could be wear particles from steel.	
	3) Intermediate rotors	Scale	-Mostly Silica and oxygen	-Primarily silica build-up from steam water contamination.	
			-Some ferrous particles (80x80μm)	-Ferrous particles could be wear particles from steel.	
	4) Turbine outlet	Debris particles	-Mostly Iron oxide	-Steel corrosion	
			-With Silica and calcium	-Steam water contamination	
			-Some zinc	-Paint or plating material	
	5) Boiler feed pump filters	Debris particles	-Mostly Iron Oxide (2x3mm)	-Steel corrosion	
			-Some particles of stainless steel	-Stainless steel wear particles	
			- Some bronze particles	-Bronze wear particles	









### **Final Conclusion**

- The erosion of the low pressure blades is due to debris from steel corrosion and silica particles being transported by the steam.
  - We identified that the input screen for the steam to the turbine had relatively large openings (~6.5 millimeters) and would not be capable of capturing small particles carried in the steam.



# Fire in Large Motor





### The Loss

- A plant used a large 2000 HP motor to shred vehicles
  - Operator started early
  - Ran the shredder until 10:30 AM
  - Noticed smoke from the building housing the motor
  - Ran down and discovered a fire in the motor







### Inspection

 Motor was removed and sent to plant for rewinding



Motor disassembly was assigned to company that performed initial rewinding 2 <sup>1</sup>/<sub>2</sub> years earlier



#### Patterns





### **Environmental Conditions**





### Site Inspection







## Machine Inspection





## **Power Supply**





# Manufacturing



- Motor was re-wound
  2 <sup>1</sup>/<sub>2</sub> years earlier
- Operated one shift (8-10 hours)



#### Service Contract

- Engineering firm performed semi-annual testing
  - Recommended maintenance
  - Suggested cleaning method
  - Verified motor was functional properly
- Motor was operated within recommendations by engineering firm



### Failure: Electrical Short





### **Cause: Insulation Failure**





#### Root Cause:

- Winding failure is caused by:
  - Thermal aging/deterioration
  - Mechanical failure
  - Electrical surges
  - Environmental factors
  - Manufacturing



### Opinion

- Eliminated all causes <u>but</u> Failure due to improper manufacturing
- Tests should have detected failure earlier, <u>if</u>
  <u>performed properly</u>

