

20th SYMPOSIUM ON INDUSTRIAL APPLICATIONS OF GAS TURBINES



BREATHING NEW LIFE INTO AN AERO-DERIVATIVE GAS
TURBINE CO-GENERATION PLANT VIA REFURBISHMENT
AND MODIFICATIONS

by

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Outline

- Introduction to StandardAero Limited
- Introduction to LHSC and the Westminster Power Plant
- Co-generation Plant Refurbishment Project Overview
- Project Challenges & Highlights
- Conclusions





Introduction to StandardAero Limited



Standard Aero Limited

- Independent provider of gas turbine engine overhaul, component repair, and customized power plant projects.
- Supporting aviation and industrial gas turbines for over 100 years.
- Service customers in over 80 countries.
- Facilities in North America, Europe and Asia Pacific.
- Extensive engineering and technical resources.
- In-house component services in world-class facilities.



Standard Aero Limited

- The Standard Aero Energy division is located in Winnipeg, Manitoba (Canada).
- Authorized gas turbine maintenance center for:
 - Rolls-Royce 501K
 - General Electric LM1600
 - Vericor TF & ASE engine families
- Authorized component repair center for General Electric and Rolls-Royce engine components.
- Perform field service, comprehensive maintenance contracts, complete package upgrades & refurbishment.



Introduction to LHSC and the Westminster Power Plant

London Health Sciences Centre

- One of Canada's largest acute care teaching hospitals since 1875.
- 15,000 employees across multiple London, Ontario sites. 1 million patient visits per year.
- LHSC Westminster Power Plant provides electrical power and steam (district heating) for LHSC Victoria & Parkwood Hospital complexes.
- Internal power generation results in over 45% savings in electrical power expenditures.



London Health Sciences Centre

- Prior to 2013, the Westminster Power Plant housed:
 - (1) 4.9 MW generator powered by a Rolls-Royce 501-KB7 gas turbine and coupled to a natural circulation heat recovery steam generator.
 - (1) 2 MW generator powered by an Elliott back pressure steam turbine.
 - (4) conventional boilers
- The plant's pre-2013 available saturated steam capacity was 88,904 kg/hr at 724 kPa (196,000 lb/hr at 105 psi).



London Health Sciences Centre

- Due to LHSC hospital expansion projects, the Westminster Power Plant was recently expanded to provide additional electrical & steam generation capacity.
- Plant expansion also sought increased equipment redundancy and reliability for optimal plant operational flexibility and operational costs.
- New equipment added includes:
 - (1) refurbished Foster Wheeler dual fuel conventional boiler, rated for 36,287 kg/hr at 724 kPa (80,000 lb/hr at 105 psi) saturated steam.
 - (1) refurbished Rolls-Royce 501-KB5S gas turbine co-generation unit rated for 3.8 MWe (at 0.92 power factor) and max. saturated steam rates of 12,927 kg/hr at 724 kPa (28,500 lb/hr at 105 psi).
 - New/redundant water & steam treatment equipment.

London Health Sciences Centre





Co-generation Plant Refurbishment Project Overview



Project Overview - General

- During the Westminster Power Plant expansion LHSC sought to source equipment that was:
 - Cost effective
 - Consistent with existing equipment for optimal plant integration.
- Standard Aero Limited (Energy division) was retained by LHSC to supply a refurbished Rolls-Royce 501-KB5S gas turbine co-generation unit as well as to perform long-term unit maintenance following commissioning.
- Market analysis revealed that a refurbished co-generation plant would provide a 30% reduction in initial capital costs (compared to equivalent fully new unit).
- Compatibility with the existing Rolls-Royce KB7 co-generation unit also allows for optimal use of plant resources.

Project Overview - 501K Engine

- The Rolls-Royce 501K engine family is an aero-derivative due its roots in the T56/501 aircraft engine.
- Introduced in 1954 for the Lockheed C-130 aircraft the Rolls-Royce T56 military turboprop has proven service history with over 18,000 units produced.
- In 1963 Rolls-Royce (then Allison) leveraged its T56 aircraft engine design to create the 501K aero-derivative engine family for industrial, marine, and electric power generation applications.
- Similar gas path components as the T56.



Project Overview - 501K Engine

- General features of 501K engines:
 - Produce up to 6450 kW_e at a gross efficiency between 29 and 40% (simple cycle).
 - Liquid and/or gaseous fuel compatible.
 - Available with water/steam injection capabilities or a dry low emissions system.
 - Offered in either a single or dual shaft configuration.
- Aero-derivatives generally feature:
 - Modular designs that are easy to maintain.
 - Increased reliability and lower costs of ownership due to improved access to spare parts (combined production volumes of flight and industrial markets).



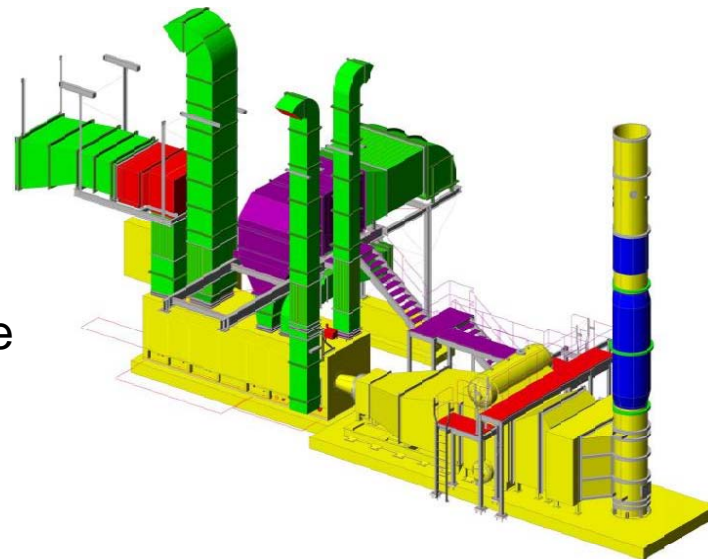
Project Overview - Plant Origin

- The refurbished Rolls-Royce 501-KB5S co-generation unit installed at LHSC originated from a shutdown printing company in California, USA.
- Commissioned in 1994 but shutdown in 2009.
- Was continuously operated outdoors and featured:
 - Rolls-Royce 501-KB5 engine.
 - HRSG with maximum steam capacity of 14,969 hg/hr at 3792 kPa and 400°C (33,000 lb/hr at 550 psi and 750°F).
 - Natural gas with water injection.
 - Black start capability.
 - SCR system.
 - 3.8 MWe generator (0.92 power factor).



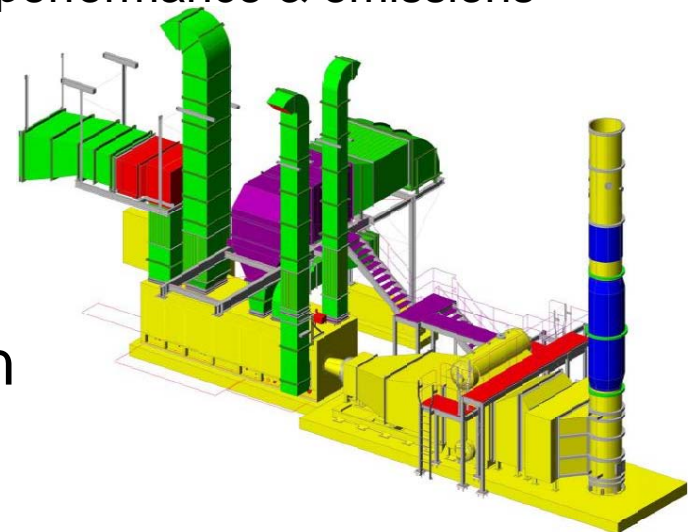
Project Overview - Scope

- Per the LHSC project requirements the following package refurbishment & modification scope was undertaken:
 - Removal of the co-generation plant from the original site (California, USA) and final transport to LHSC in London, Ontario (Canada).
 - Modification and re-certification of the HRSG boiler for 724 kPa (105 psi) saturated steam output pressure per applicable Canadian standards.
 - Conversion of the turbine enclosure to the 501-KB5S engine configuration (natural gas fuel with water injection).
 - New generator protection equipment, upgraded switchgear, and integration with the existing plant electrical systems.
 - New control system for the gas turbine unit and for the HRSG.



Project Overview - Scope

- (scope - continued)
 - Design and manufacture of stack silencers for to meet LHSC local noise emissions requirements.
 - Re-certification of the co-generation unit electrical system per the Ontario Electrical Safety Code regulations.
 - Full site commissioning of all the refurbished Rolls-Royce 501-KB5S co-generation plant sub-systems and final site performance & emissions qualification testing.
- CEM Engineering performed the balance of the plant engineering design as part of the general LHSC Westminster Power Plant expansion construction project.





Project Challenges & Highlights



Project Challenges & Highlights

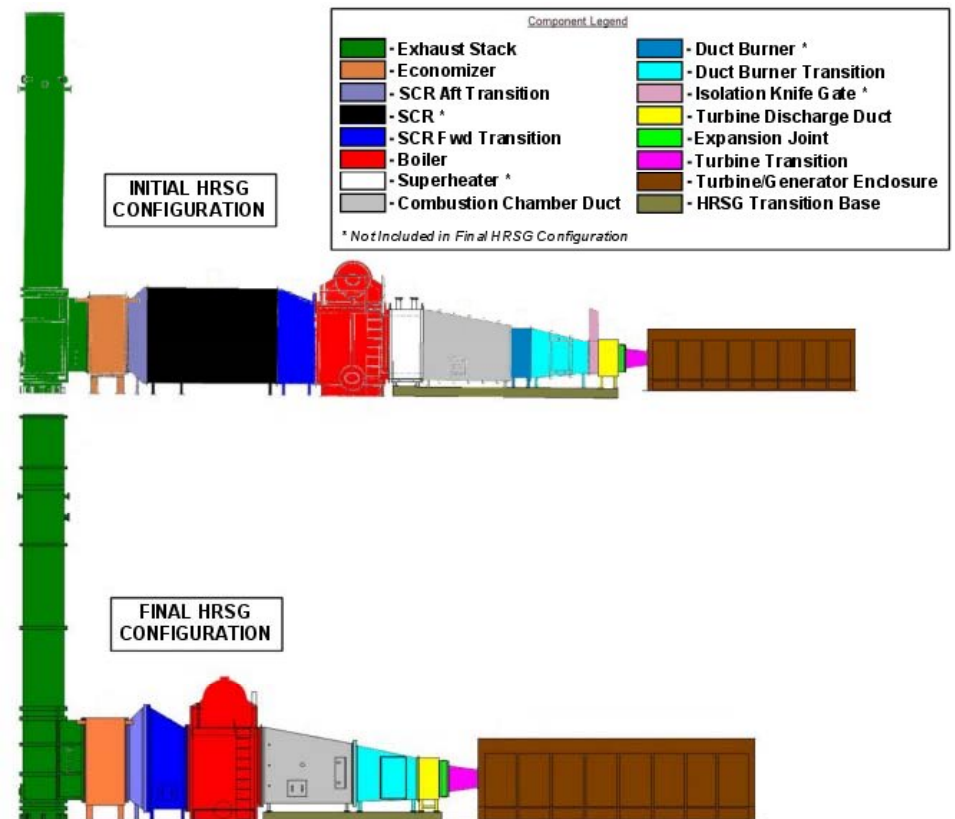
- Co-Generation Plant Re-Location:
 - In some cases the mounting bolts and studs of various sub-components required cutting using welding torches due to excessive corrosion damage.
 - The general corrosion damage was repaired and new surface protection coatings were applied.
 - Project coordination with LHSC's overall Westminster Power Plant expansion wing construction project completion schedule required temporary storage of the refurbished co-generation plant components.



Project Challenges & Highlights

- HRSG Conversion & Re-Certification:

- Removal of the:
 - Duct Burner
 - SCR
 - Superheater
 - Isolation Knife Gate
- Steam drum nozzles and pressure relief safety valves modifications for LHSC target 724 kPa (105 psi) saturated steam output pressure.
- Full safety certification per Canadian safety code.
 - Had to reverse engineer the unit due to lack of original design drawings.
- New boiler trim equipment.



Project Challenges & Highlights

- Electrical Equipment Integration & Certification:
 - Due to difference in Canadian & American electrical standards a step-up voltage transformer was added between the MCC and the plant electrical motors (575 VAC vs. 480 VAC).
 - Per the Canadian electrical code requirements the turbine enclosure was modified for explosion proof certification (Class I, Division 2, hazardous environment).
 - Upgrades to the LHSC plant and local utility electrical distribution systems to handle additional current flows of the 3.8 MWe electrical generator.
 - Multiple entities involved with upgrades & certification.
 - Deregulated electrical market in Ontario.
 - Required careful coordination of activities (proved challenging).



Project Challenges & Highlights

- Water Injection Re-Commissioning:
 - During an abnormally cold (-20°C or -4°F) day during the plant re-commissioning activities, water freezing was experienced in some sections of the gas turbine water injection system.
 - Due to original placement of system components (suitable for California but not optimal for LHSC).
 - Problem corrected by re-locating system components to a temperature regulated area.



Project Challenges & Highlights

- Final Re-Commissioning:
 - In May 2012, the refurbished co-generation unit began installation at LHSC and major re-commissioning of the unit was completed in November 2012.
 - Gas turbine water injection control system was tuned to meet LHSC's local exhaust stack emissions of 52.9 ppm NO_x and 60 ppm CO (dry basis and normalized to 15% O₂) at maximum plant rated conditions.



Conclusions

Conclusions

- Use of refurbished power plant equipment can be a cost effective alternative for meeting expanded site electrical and thermal energy requirements.
- Partnering with comprehensive service providers for both initial commissioning and long-term maintenance of the unit can lower project risk and ensure long-term reliability of refurbished equipment.
- Use of experienced local contractors is vital to overall project success.



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