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## Degradation Curves for Heavy Duty Product Line Gas Turbines

Combined cycle performance loss during extended operational periods is largely due to compressor fouling. The rates of both compressor fouling and performance loss are a result of the variation in environmental conditions, fuel used, machine operating scenario and maintenance practices.

Performance loss during normal operation is minimized by periodic on-line and off-line compressor water washes. Performance loss during extended operation is expected to be greater for plants that are located in humid and/or contaminated industrial environments. Also, plants operated under non-ideal running scenarios, along with neglected or poorly performed maintenance practices can be expected to exhibit increased performance losses. Plants that are sited in relatively clean less humid environments, operated within equipment design recommendations and cleaned with regular on and off-line compressor washes will experience less performance degradation.

Performance recovery, beyond that which occurs with normal maintenance, including on and off-line washes, can be achieved following other off-line procedures. One procedure in particular involves removing both the compressor and turbine casing to accommodate hand scouring of the compressor rotor and stator airfoils. Compressor inlet air filter cleaning/replacement, along with other required maintenance, may also be performed during these inspections. Such an outage would most likely coincide with hot gas path or major inspection intervals, since significant machine disassembly is required.

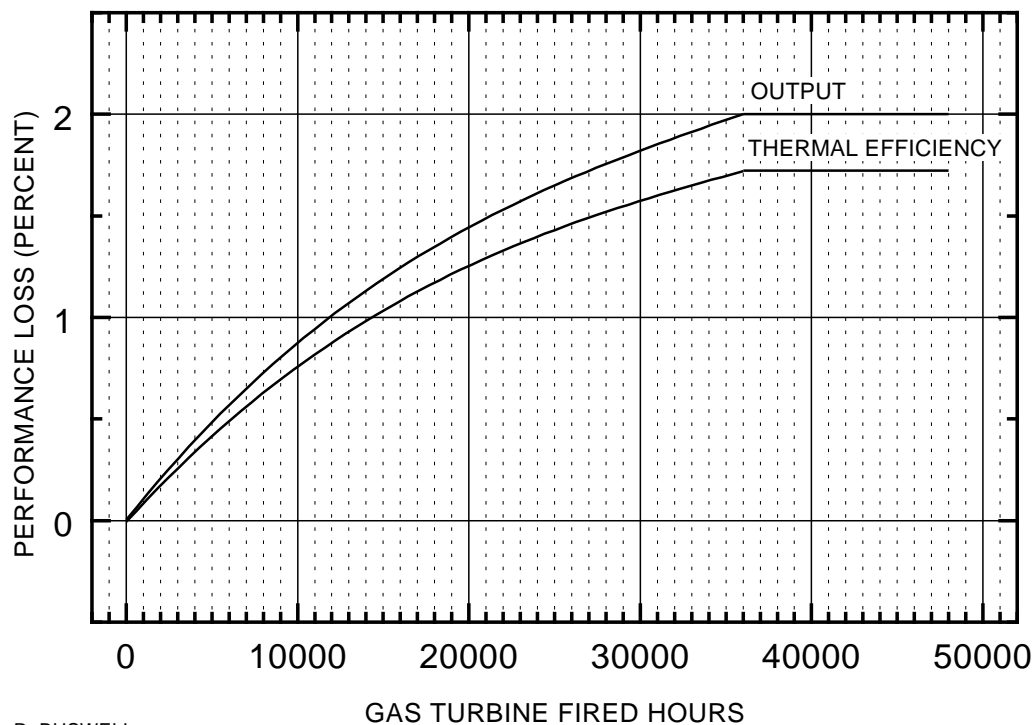
A typical combined cycle plant operation profile, reflecting on- and off-line maintenance procedures, is presented in the attached figures. Plant performance degradation during normal operation is cyclic as impacted by on- and off-line compressor water washes. Drawing 519HA773 represents expected performance loss, in accordance with the stated basis for operation, maintenance and testing procedures. Note that this curve represents the locus of points following specific shut down maintenance activities, not actual continuous on-line operating capability. Drawing 519HA745 represents a comparable locus of data following the more extreme machine disassembly and hand scouring procedure.



## EXPECTED COMBINED CYCLE PLANT NON-RECOVERABLE PERFORMANCE LOSS DURING EXTENDED PERIOD OPERATION

THE AGED PERFORMANCE EFFECTS REPRESENTED BY THESE CURVES ARE BASED ON THE FOLLOWING:

- \* PERFORMANCE IS RELATIVE TO THE GUARANTEE LEVEL.
- \* ALL COMBINED CYCLE PLANT EQUIPMENT SHALL BE OPERATED AND MAINTAINED IN ACCORDANCE WITH GE'S RECOMMENDED PROCEDURES FOR OPERATION, PREVENTIVE MAINTENANCE, INSPECTION AND BOTH ON-LINE AND OFF-LINE CLEANING.
- \* ALL OPERATIONS SHALL BE WITHIN THE DESIGN CONDITIONS SPECIFIED IN THE RELEVANT TECHNICAL SPECIFICATIONS.
- \* A DETAILED OPERATIONAL LOG SHALL BE MAINTAINED FOR ALL RELEVANT OPERATIONAL DATA, TO BE AGREED TO AMONGST THE PARTIES PRIOR TO COMMENCEMENT OF CONTRACT.
- \* GE TECHNICAL PERSONNEL SHALL HAVE ACCESS TO PLANT OPERATIONAL DATA, LOGS, AND SITE VISITS PRIOR TO CONDUCTING A PERFORMANCE TEST. THE OWNER WILL CLEAN AND MAINTAIN THE EQUIPMENT. THE DEGREE OF CLEANING AND MAINTENANCE WILL BE DETERMINED BASED ON THE OPERATING HISTORY OF EACH UNIT, ATMOSPHERIC CONDITIONS EXPERIENCED DURING THE PERIOD OF OPERATION, THE PREVENTIVE AND SCHEDULED MAINTENANCE PROGRAMS EXECUTED, AND THE RESULTS OF THE GE INSPECTION.
- \* THE COMBINED CYCLE PLANT WILL BE SHUT DOWN FOR INSPECTION AND MAINTENANCE WITH COMPRESSOR ROTOR AND STATOR SCOURING, AS A MINIMUM, IMMEDIATELY PRIOR TO PERFORMANCE TESTING TO DETERMINE PERFORMANCE LOSS. THE COMBINED CYCLE PERFORMANCE TEST SHALL OCCUR WITHIN 100 FIRED HOURS OF THESE ACTIONS.
- \* DEMONSTRATION OF GAS TURBINE AND COMBINED CYCLE PLANT PERFORMANCE SHALL BE IN ACCORDANCE WITH TEST PROCEDURES WHICH ARE MUTUALLY AGREED UPON.

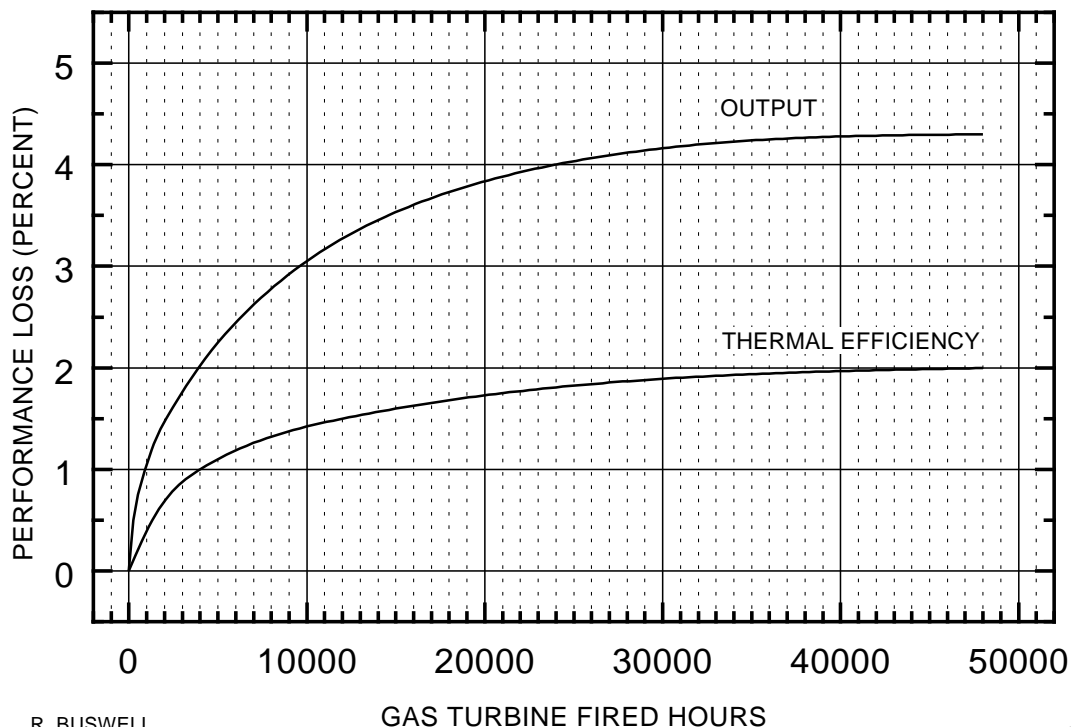


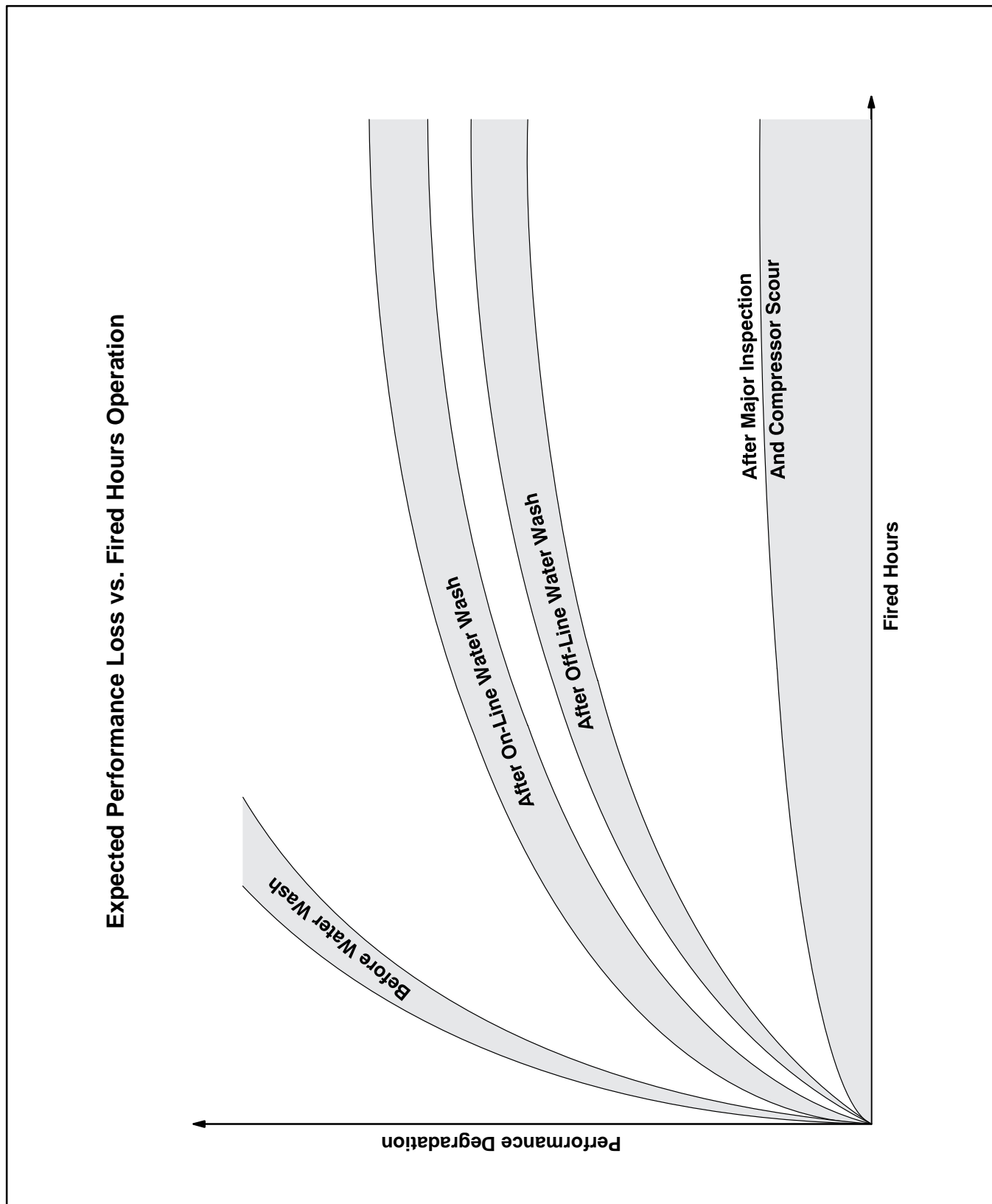


## EXPECTED COMBINED CYCLE PLANT PERFORMANCE LOSS FOLLOWING NORMAL MAINTENANCE AND OFF-LINE COMPRESSOR WATER WASH

THE AGED PERFORMANCE EFFECTS REPRESENTED BY THESE CURVES ARE BASED ON THE FOLLOWING:

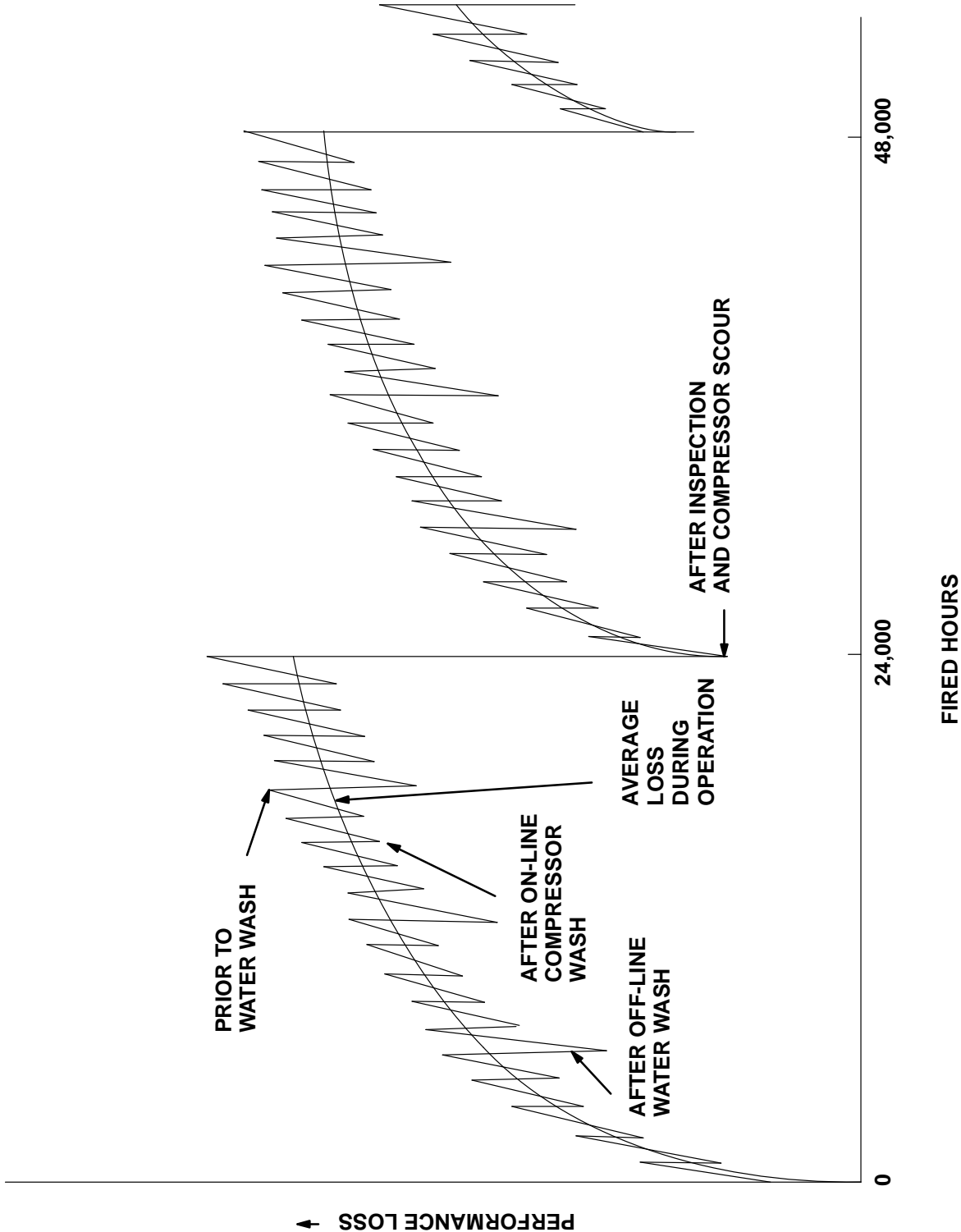
- \* PERFORMANCE IS RELATIVE TO THE GUARANTEE LEVEL.
- \* ALL COMBINED CYCLE PLANT EQUIPMENT SHALL BE OPERATED AND MAINTAINED IN ACCORDANCE WITH GE'S RECOMMENDED PROCEDURES FOR OPERATION, PREVENTIVE MAINTENANCE, INSPECTION AND BOTH ON-LINE AND OFF-LINE CLEANING.
- \* ALL OPERATIONS SHALL BE WITHIN THE DESIGN CONDITIONS SPECIFIED IN THE RELEVANT TECHNICAL SPECIFICATIONS.
- \* A DETAILED OPERATIONAL LOG SHALL BE MAINTAINED FOR ALL RELEVANT OPERATIONAL DATA, TO BE AGREED TO AMONGST THE PARTIES PRIOR TO COMMENCEMENT OF CONTRACT.
- \* GE TECHNICAL PERSONNEL SHALL HAVE ACCESS TO PLANT OPERATIONAL DATA, LOGS, AND SITE VISITS PRIOR TO CONDUCTING A PERFORMANCE TEST. THE OWNER WILL CLEAN AND MAINTAIN THE EQUIPMENT. THE DEGREE OF CLEANING AND MAINTENANCE WILL BE DETERMINED BASED ON THE OPERATING HISTORY OF EACH UNIT, ATMOSPHERIC CONDITIONS EXPERIENCED DURING THE PERIOD OF OPERATION, THE PREVENTIVE AND SCHEDULED MAINTENANCE PROGRAMS EXECUTED, AND THE RESULTS OF THE GE INSPECTION.
- \* THE COMBINED CYCLE PLANT WILL BE SHUT DOWN FOR INSPECTION AND OFF-LINE COMPRESSOR WATER WASH, AS A MINIMUM, IMMEDIATELY PRIOR TO PERFORMANCE TESTING TO DETERMINE PERFORMANCE LOSS. THE COMBINED CYCLE PERFORMANCE TEST SHALL OCCUR WITHIN 100 FIRED HOURS OF THESE ACTIONS.
- \* DEMONSTRATION OF GAS TURBINE AND COMBINED CYCLE PLANT PERFORMANCE SHALL BE IN ACCORDANCE WITH TEST PROCEDURES WHICH ARE MUTUALLY AGREED UPON.







Expected Gas Turbine and Combined Cycle Performance Loss vs. Fired Hours





# Expected Gas Turbine and Combined Cycle Performance Loss vs. Fired Hours

