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BY THE NUMBERS: Pedigree and performance…The 'Test of Champions'

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On June 9, 1973, history was made in Elmont, NY, the town just outside of New York City famous for hosting the Belmont Stakes. That day, a crowd of 67,605 racing enthusiasts, plus another 10.9 million watching on TV, waited to see if a three-year-old thoroughbred named *Secretariat,* chestnut brown with a strong pedigree, would take the Triple Crown—a coronation that had not occurred since 1948.

Secretariat, would not disappoint in the "Test of Champions."

The Belmont Stakes, the longest of the three Triple Crown races at 1½ miles, is a test of agility, speed, power, and endurance. The opportunity to challenge for the Triple Crown begins with wins at the Kentucky Derby (1¼ miles) and the Preakness Stakes (1 3/16 miles). Within a two-week period, *Secretariat* had won both the Derby and Preakness by 2½ lengths over a formidable contender named *Sham*, which also came from a strong pedigree. He might have been a Triple Crown contender at a different moment in time.

Three weeks after the Preakness, only *Sham* and three other horses were in the Belmont starting gate with *Secretariat,* hoping to spoil his chance for a Triple Crown and continue the 25-yr drought.

It was not to be.

1^{hd}, 1^{hd}, 1^{7}, 1^{20}, 1^{28}, 1^{31}. After a fast start, *Secretariat* was leading *Sham* by a head at the first quarter pole. He maintained that lead through the half and then began pulling away. "Big Red" blew by the mile pole seven lengths ahead of *Sham* and the challenger faded. He would finish last.

Secretariat extended his lead to 20 lengths over the next quarter of a mile, increased it to 28 lengths down the stretch, and finished 31 lengths ahead of *Twice a Prince* in record time. The 2:24 *Secretariat* logged that day still stands as a world record for the mile and a half on a dirt track.

Many people who saw that race still feel the excitement in the voice of Belmont Announcer Chick Anderson, "*Secretariat* is alone: He is moving like a tremendous machine!"

Another tremendous machine

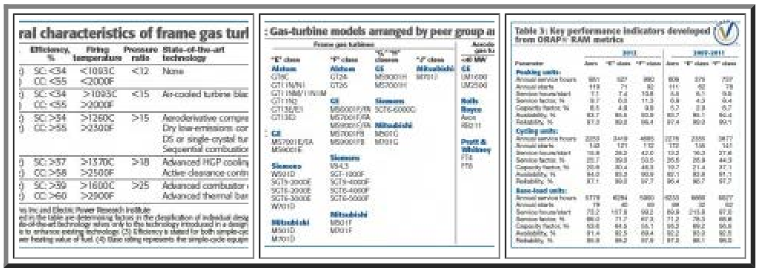
The energy industry continues to advance, in large part, because of tremendous *machines,* gas turbines (GTs) in particular, whose pedigree and performance improve to meet the demands of an ever-changing and challenging market. Today's drivers influencing operations and maintenance, as well as new product design, include the following:

- Fast start-up times.
- Impact of cyclic duty on parts life and maintenance schedules.
- Load-following and –shedding to the lower and lower outputs required to accommodate swings associated with intermittent renewables, all while continuing to meet rigorous emissions standards.
- The value of reserve or "sitting" capacity.

For owners and OEMs alike, success depends on the flexibility and responsiveness of their machines to start and reach rated power in less time than the competition, and to do so more efficiently and more reliably over time and within operating constraints imposed by regulations. In effect, to have the opportunity to be "in the money" at all times. This, too, is a "Test of Champions."

Table 1 charts the evolution of the "heavy duty" (more commonly referred to today as "frame") GTs by class, or pedigree, from the legacy engines to "J" class. For these machines, product evolution is characterized by output, thermal efficiency, firing temperature, compressor ratio, and use of the latest technologies available—such as enhanced airfoil cooling, ultra-low-emissions combustion, and advanced metallurgy.

For aeroderivative product offerings, the pedigree has evolved from an aviation heritage, drivers of advancements in technology, addressing similar design issues and constraints as these products are placed in land-based applications.



OEM product offerings fit into the pedigree classes or "peer groups" shown in Table 2. Engines in each class compete based on installed cost, O&M cost, and performance (both thermal and operational).

To compare operational performance by pedigree, data extracted from the Operational Reliability Analysis Program (ORAP®) are presented in Table 3. Reliability/availability/maintainability (RAM) are shown for the aeroderivative, "E," and "F" classes of engines characterized in the first two tables.

The metrics presented were developed from data gathered across the globe from plants operating in various duty cycles that participated in the ORAP program in 2012, as well as during 2007-2011. The information is presented by peer group and by duty cycle. The latter is indicative of the mission profile that these units must meet and are represented by the following parameters:

- Annual service hours.
- Annual starts.
- Service hours per start.
- Service factor.
- Capacity factor.
- Availability.
- Reliability.

Here's an assessment by SPS engineers of the data included in Table 3:

Peaking units. Units that have historically operated in a peaking duty cycle offer some interesting comparisons when comparing 2012 performance to average annual data for the prior five-year period (2007-2011). They are:

- In 2012, peaking units across all classes (aeroderivative, "E," and "F") had significantly more annual service hours than they did in 2007-2011. Specifically, both aero and E peakers ran about 40% more service hours in 2012 than in the previous five-year period, "F" class units about 34% more.
- The mission profile for peakers across all peer groups in 2012 compared to 2007-2011 reflects more starts, more service hours per start, and higher capacity factors. Yet, as expected, these units were in reserve standby for most of last year: 7358 hours for aeros, 7840 hours for "E" class units, 7236 for "F."
- Availability and reliability factors are very consistent period over period. For both 2012 and 2007-2011, planned and unplanned maintenance were the primary drivers of unavailability for all classes. Last year they contributed 315 downtime hours for aeros, 307 for "E" class units, and 394 downtime hours for "F" class.

Cycling units also provide some noteworthy comparisons for the two time periods:

- Both classes of frames ran more hours in 2012 than they did in the earlier period: "E" engines about 45% more service hours, "F" class about 21% more. Aeros operated consistently. Service hours in 2012 decreased by only about 1% compared to 2007-2011.
- "E" and "F" engines operated substantially more service hours per start in 2012—73% and 52%, respectively—over 2007-2011 levels. This reflects a significant increase in unit demand. Aeros also ran more service hours per start in 2012, but had the smallest increase of the peer groups (about 20%).

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• All classes experienced fewer annual starts in 2012—about 17% less for aeros and about 20% less for “E” and “F” class units. Also important to note is that the demand profile for all classes of cycling units does not show 200 annual starts. Service factors and capacity factors for cycling units increased period over period, indicating a change in demand or mission profile.

• In 2012, only aeros improved in both availability and reliability, compared to 2007-2011. They had about 61 fewer forced-outage hours and seven more days of availability in 2012 when compared with the previous period.

For “E” and “F” class cycling units, as for the peakers in those peer groups, planned and unplanned maintenance was the primary driver of unavailability. In 2012, maintenance accounted for 499 downtime hours among the “E” class machines and 596 downtime hours for “F” class units. The impact of cycling duty on maintenance is evident in these results. The aeros were only charged with 272 hours of downtime related to planned and unplanned maintenance in 2012.

Base-load units produced these results:

In 2012, each peer group operated fewer service hours than it did in 2007-2011. Aero and “E” units ran 7% and 8% fewer hours, respectively; “F” engines were off 2%.

Service hours per start for both aeros and “F” class units were relatively consistent period over period. By contrast, the service hours per start for “E” machines in 2012 decreased by a whopping 26% from 2007-2011.

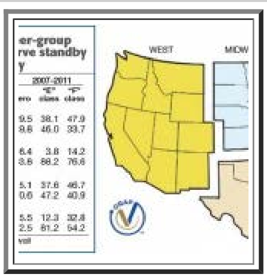
In 2012, aeros had 10 fewer starts than they averaged in the previous period, while “E” engines had eight more starts and “F” engines had three fewer starts. Capacity and service factors were relatively high and consistent period over period.

Availability decreased slightly for each unit class in 2012. For the frame engines, the decrease was caused by an increase in the amount of planned and unplanned maintenance, period over period—53 hours for “E” machines and 263 hours for “F” units. For aeros, availability dropped because of an increase in forced-outage time of about four days.

Regional impacts. To better understand how operating paradigms vary with region, SPS engineers compared capacity factor and reserve standby factor data for aero and “E” and “F” class gas turbines in the Northeast, South, Midwest, and West (Table 4).

• Aeros and “E” class frames in the West and Northeast had higher capacity factors and lower reserve standby factors than like engines located in the Midwest and South. Capacity factors for aeros increased, and reserve standby factors decreased, from the 2007 to 2011 period to 2012 in the Midwest and Northeast. For “E” machines, capacity factors increased in all regions between 2007 to 2011 and 2012 except the West; the converse was true for the reserve standby factors.

• Capacity factors for “F” class units nationwide increased between the 2007-2011 period and 2012; by contrast, reserve standby factors decreased.



While past performance may not predict future performance, it does matter and should be understood because it sets market expectations and establishes the baseline for product improvement.

Past performance can be something to admire. By the end of *Secretariat’s* short two-year career, he had run in 21 races, compiling 16 wins, three seconds, and one third-place finish. He was in the money 95% of the time, winning more than $1.3 million and ringing up an additional $6 million through syndication as a stallion—a world-record amount at that time.

Pete Axthelm of Newsweek magazine wrote: “If there is urgency in every 26-ft stride that *Secretariat* takes, there is also a rich, meandering history behind him; it is a tale of hope and vision, painstaking work, and superb performance under pressure. . . .”

Sounds a lot like the gas-turbine industry. **CCJ**

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