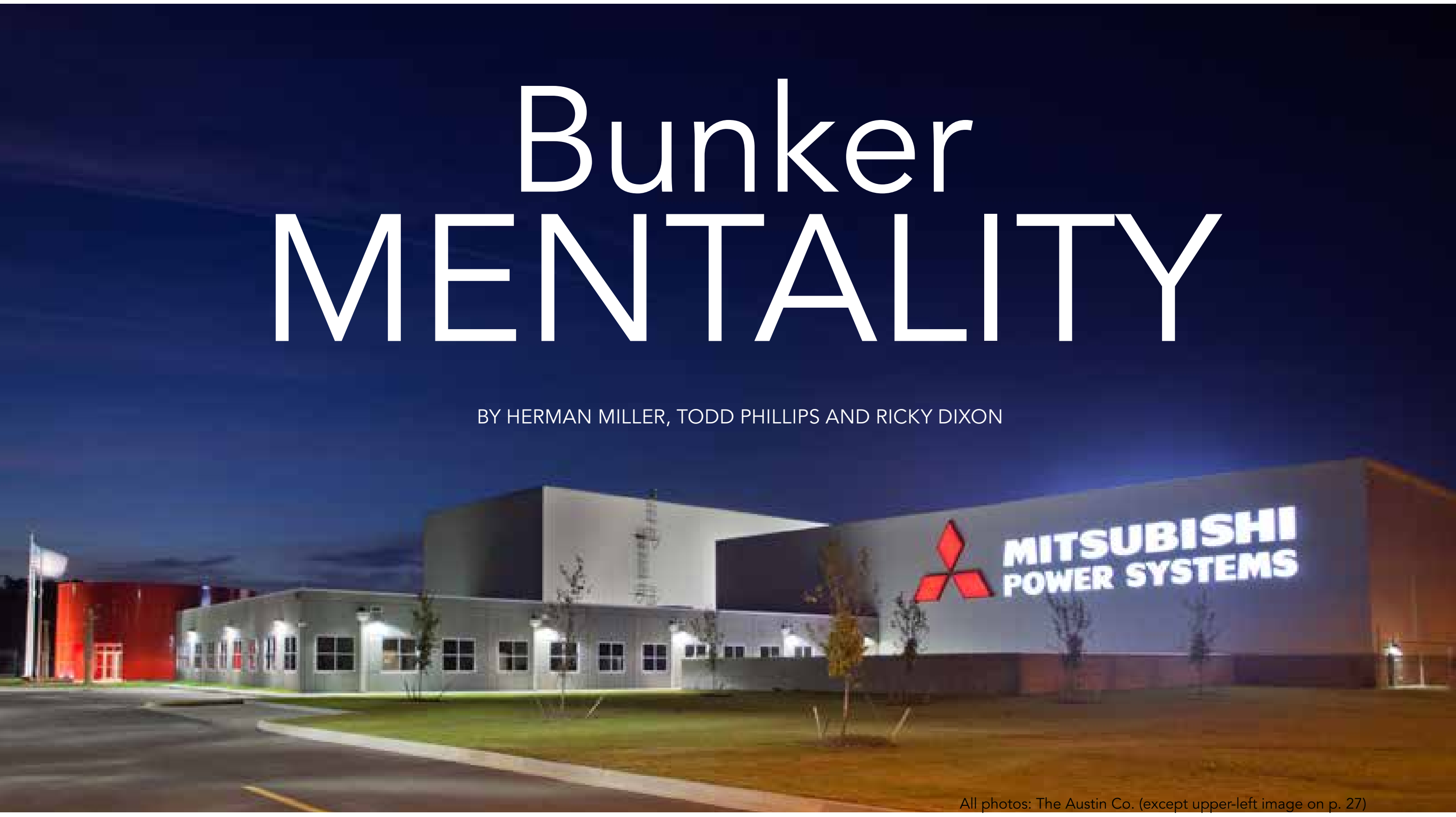
A massive steel-framed bunker is the centerpiece of a new gas turbine testing facility.

Bunker MENTALITY

BY HERMAN MILLER, TODD PHILLIPS AND RICKY DIXON



All photos: The Austin Co. (except upper-left image on p. 27)

MITSUBISHI POWER SYSTEMS America (MPSA) is turning up the heat on its turbine production.

Due to increased demand for its products and services across the North American market, the company needed to increase production of its key gas turbine parts, provide complete steam turbine services and assemble advanced fuel-efficient gas turbines for the gas and steam market. In response, it hired the joint venture team of H.J. High Construction and Batson-Cook Construction to design and build a new manufacturing and testing facility near Savannah, Ga. Subsequently, The Austin Company was hired to provide architectural design and engineering services (Batson-Cook is one of Austin's sister companies).

The 116-acre Machinery Works Premier Service and Manufacturing Center—a comprehensive service and repair center for gas turbines, steam turbines and generator rotors—was designed and built in several phases over four years and includes over 440,000 sq. ft of heavy industrial manufacturing facilities, offices and a turbine balancing and testing facility referred to as the Balance Bunker; the latter is one of only 12 such facilities in the world.

The project phases included:

- Manufacturing Building – Bays 1 and 2 – 137,500 sq. ft
- Manufacturing Building – Bay 3 – 75,600 sq. ft
- Manufacturing Building – Bay 4 – 76,300 sq. ft
- Manufacturing Building – Bay 5 – 72,000 sq. ft
- Balance Bunker Vacuum Chamber – Turbine Balancing/Testing Facility – 20,000 sq. ft
- Office Building – 31,700 sq. ft
- Office/Conference Center – 17,000 sq. ft
- Guardhouse and Maintenance Building – 10,000 sq. ft

Crane Considerations

The load demand of the multiple bridge cranes, along with the overall building size, were the factors that drove the decision to use structural steel framing for this project; the buildings feature structural steel framework with 2-in. insulated metal wall panels. Other types of structures, such as cast-in-place concrete or precast concrete, were eliminated due to cost.

The manufacturing building required clear heights of over 70 ft and clear spans of up to 90 ft. Bay 2 has a 30-ton crane that only operates in about 100 ft of the bay, and Bay 3 has two, 150-ton cranes that run the entire length of the building; they were designed to be used in tandem for a total lifting capacity of 250 tons. The load requirements in Bay 4 had the most significant impact on the steel design. This bay is designed to have two 30-ton cranes running on a lower runway along the entire length of the building, and two 250-ton bridge cranes that are designed to be used in tandem when loaded with a complete turbine assembly (weighing a total of 450 tons). Bay 5 was designed for two 30-ton cranes and one 60-ton crane on an upper runway, and nine 15-ton gantry cranes running on a lower track.

On average, each bay took ten months to construct. In order to meet the tight timeline and help maintain this momentum, the steel was fabricated in the order in which it was to be erected. Several sequences of steel deliveries were scheduled so that no steel sat on the ground for more than three days before it was installed.

Nearly 6,100 tons of steel was used to complete the entire project.

The new facility includes more than 440,000 sq. ft of space spread out over multiple phases.

The balance bunker uses more than 1,500 tons of structural steel, including 62 tons for the sole plates inside the chamber and 16 tons for the base plates for the drive equipment.

Nearly 6,100 tons of steel was used to complete the project, including approximately 4,900 tons of wide-flange and 1,200 tons of steel joists. The manufacturing building required more than 4,500 tons of steel while the Balance Bunker involved more than 1,500 tons, including 62 tons for the sole plates inside the chamber and 16 tons for the base plates for the drive equipment. In addition, nearly 45,000 cubic yards of concrete was cast on the project for equipment foundations, large slab pours and the Balance Bunker. Coatings included Sherwin-Williams Steel-Spec FHP Universal Primer; Finish (B50WV8000 White) for all exposed steel and as a final coat; and Carboline Carboguard 890 Cycloaliphatic Amine Epoxy for the interior of the Balance Bunker.

Repetitive Design

The design-build project used BIM and Tekla 3D modeling to support project team collaboration, and SteelFab, Inc., the fabricator, used a Tekla 3D program that was imported into The Austin Company's AutoCad 3D Model to produce a complete 3D model for the manufacturing building. In addition, Austin used AutoCad 3D for the Balance Bunker to help review the structure with the owner and confirm that the building met its requirements.

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▲ The manufacturing building has five bays in all.

▼ On average, each bay took ten months to construct.

The Tekla 3D model was reviewed during meetings with the design team as a visual aid to illustrate design issues and to develop solutions. Overall, the project did not involve complex geometry, but it did have a high degree of repetitious framing. As subsequent bays were released for construction, the team was able to quickly build on to the previous Tekla 3D model. The team was able to copy elements from similarly designed areas of the legacy model, make the requisite modifications to conform to the current bays' design—typically due to different crane requirements—and quickly produce approval documents.

Having the previous bays' model information was also useful when coordinating the connection of a new bay to the existing structure. The team was able to visualize the outcome and avoid clashes and accessibility issues that may have gone unnoticed until erection commenced.

Critical Balance

One of the most critical components of the overall project was the Balance Bunker. This complex vacuum chamber facility involved the design and construction of 7-ft, 3-in.-thick bunker walls consisting of steel framing and ½-in.-thick inner and outer steel linear plates with a reinforced concrete infill. An 8,000-hp electric motor turns the 22-ft-diameter rotors during balancing at speeds of 4,000 rpm, and a 400-ton, 3-ft, 6-in.-thick steel frame door with reinforced concrete infill seals the Bunker during testing. Railcars move the turbine rotors from Bay 3 into the Balance Bunker for testing. Following testing, the rotors are then moved to Bays 4 and 5 for final assembly and finishing.

Blast design was a major consideration for the Balance Bunker. The thick concrete, steel plate-lined walls of the Bunker protected the outside area from the risk of projectiles that could occur if there was a malfunction

◄ The new facility sits on 116 acres.

The manufacturing building required clear heights of over 70 ft and clear spans of up to 90 ft.

of the rotor during the testing and balancing operation. As such, a stray part during testing would be contained within the Bunker and not damage any of the surrounding building or endanger anyone in the Bunker area.

The Bunker's chamber is designed to maintain a near-absolute vacuum during balancing and testing, which necessitated that the thousands of feet of internal welds were designed and tested to maintain an airtight seal. The Balance Bunker walls are reinforced with two layers of #10 rebar at 6-in. vertical and horizontal on each face, and the inner steel plates were fully welded (and each millimeter of weld was vacuum tested). The internal steel linear plating anchoring was designed to resist a 2,100 psf vacuum load and a thermal design load resulting from a 100 °F rise in internal surface temperature during testing.

The massive Bunker door was developed to roll along a hydraulic track, be pushed into place horizontally using hydraulic cylinders and vacuum-sealed with a specially designed, bunker-sized rubber gasket. In addition, two stairways and a railcar bridge leading into the Bunker were designed with hydraulic lifts to move out of the door's way when closing. Due to its mass, the door was built in sections and transported to the jobsite to be installed piece by piece. The door was made of ½-in.-thick steel plate and fully welded like the inner chamber, then filled with concrete; it also had rebar installed at 6 in. on center.

Following more than four years of design and construction work, the MPSA facilities were successfully completed on schedule and opened last summer. While the project involved numerous challenges, including the many unique design aspects of the Balance Bunker, the team's approach resulted in a world-class facility that enables MPSA to provide high-quality parts and services across the continent. ■

Owner
Mitsubishi Power Systems America, Pooler, Ga.

Design-Build General Contractor
H.J. High Construction, Orlando, Fla., and
Batson-Cook Construction, Atlanta (joint venture)

Architect
The Austin Company, Cleveland, Ohio

Structural Engineer
The Austin Company (Balance Bunker and Manufacturing Building foundations)
KingGuinn Associates, Charlotte, N.C. (Manufacturing Building framing)

Steel Fabricator, Detailer and Erector
SteelFab, Inc., Charlotte (AISC Member/AISC Certified Fabricator)

The turbine balancing and testing facility is referred to as the Balance Bunker; there are only 12 such facilities in the world.