Laboratory Systems Catalog

Designed and Manufactured in the USA

EDUCATION AND RESEARCH

Spring/Summer 2013

RankineCycler™ Steam Turbine Power System

TurboGen™ Gas Turbine Electrical Generation System

PumpLab™ Centrifugal Flow/Process Control System

SprayView™ Fuel Atomization Verification System

TrueStructures™ Strain Analysis System

Creating Educational Laboratory Equipment for Tomorrow's Engineer

Turbine Technologies, LTD.

www.turbinetechnologies.com

25 Years In The Making

For a quarter century, Turbine Technologies, Ltd. has quietly been designing and manufacturing some of the world's finest and most exciting educational systems to help today's sophisticated faculty train tomorrow's successful engineer.

IMAGINE THE POSSIBILITIES…

Engineering students today have more choices than ever for their education, and the best tools can make a significant difference in a program's success. Whether for curriculum, research or student recruitment; there's never been a better time to elevate your program with quality lab equipment from Turbine Technologies.

Perry and Todd would be delighted to answer any product or delivery questions you may have. Give us a call or send us an email. We've been providing the level of quality and service that the world's best programs have come to expect – 25 years strong.

Visit our website for more information
www.turbinetechnologies.com

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What Do End-Users Have To Say About Turbine Technologies, Ltd.?

" My experience in doing business with TTL for the benefit of Penn State students is indeed rewarding. After ten years of operation, the thrust calibration of our SR-30 (gas turbine engine) remains unchanged, and experiments with the PumpLab firmly establish the principles of dimensional analysis in our turbo-machinery course; Not only the quality of the labs, but also the customer support and goodwill of TTL personnel have enabled countless enhanced learning experiences at PSU."

Dr. Horacio Perez-Blanco
Professor of Mechanical Engineering • The Pennsylvania State University

"The University of Bahrain purchased two products from Turbine Technologies, LTD, namely; the Rankine Cycler and the Centrifugal Pump unit for the Fluid Mechanics Laboratory. These units enhanced students awareness of real life understanding of steam power generation and turbo machinery working principles due to near production-scale features, including updated technology built into these units. Over years of use, the two products have shown high reliability and maintainability. In addition, after sales technical and consultative support from the factory was excellent".

Dr. M. Bassam Nabhan
Fluid Mechanics Laboratory Coordinator • Department of Mechanical Engineering
University of Bahrain

"The RankineCycler™ is the best tool on the market for laboratory teaching of thermodynamic principles and power generation, and it comes with the lowest price tag. In fact, as far as I can tell, it is the only available educational equipment of its kind."

Dr. Andrew Gerhart
Associate Professor of Mechanical Engineering • Lawrence Technological University

Designed and Manufactured in the USA

Product Index

Specifications and pricings are subject to change without notice.

NEW!

WindLab™

Wind Turbine Power System

A complete wind turbine electrical generation system, housed in a flow tunnel, featuring a three-phase generator and an on-board programmable wind speed source.

Product Summary

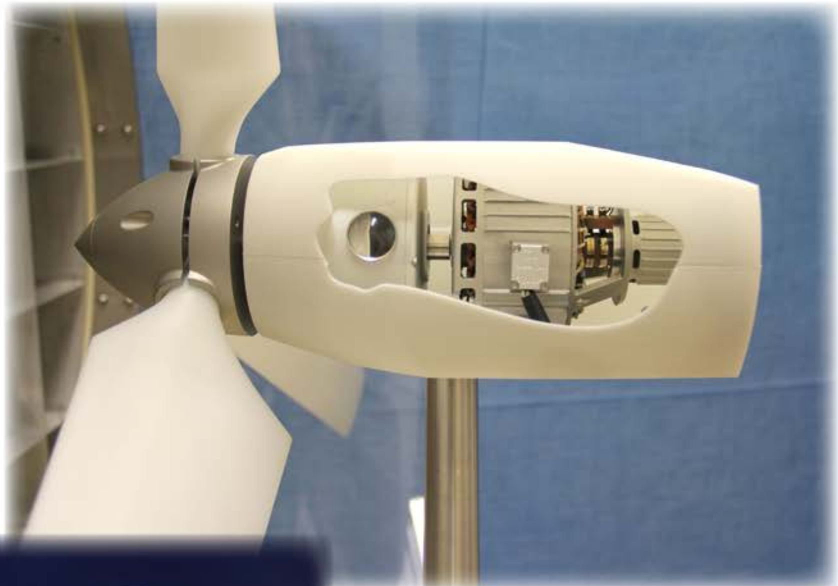
- Programmable, Variable Speed Wind Source
- Modern, Real World Blade Design
- Hub Accepts Custom Blades for Performance Comparison Testing
- All Alloy, Commercial Grade Planetary Gear Box
- Purpose-Built Three-Phase Generator with DC Excited Eight Pole Rotor and Stator
- Adjustable Resistive Load for Each Phase
- On Board Sensors and National Instruments™ Data Acquisition System
- LabVIEW™ Generated and User Configurable Virtual Instrument Panel
- Complete, Turn-Key System - Ready to Start Teaching Upon Delivery
- Industry Leading Warranty with Unsurpassed Customer Support
- Designed and Manufactured in the USA

Description

A complete, portable, self-contained three phase wind turbine electrical generation power system designed for engineering education and research. All major components of a full-scale wind turbine power system are replicated for hands on study.

Although miniature in scale, students are able to experience the full scope of real world wind turbine three phase electrical power generation principles. The system features a programmable speed wind fan and wind tunnel enclosure. The wind is ducted through a straightener vane to remove fan induced air rotation, providing a more real world wind flow pattern. Wind speed is measured by a wind anemometer. The scale, one meter wind turbine features an industry standard three bladed configuration, with manual pitch adjustment. Blades can be interchanged with alternate air-foil spec blades for performance investigation purposes.

The turbine rotor shaft drives a commercial grade all-alloy planetary gear box, which increases turbine rotor shaft RPM by 3.99 times to drive the generator at a higher RPM. The purpose built three phase generator features a DC excited, eight pole rotor and an eight pole, three phase stator. The wind turbine generator gondola nacelle features a built in "cutaway" section to allow the generator to be viewed during operation. Three operator-controlled rheostats allow independent resistive load adjustment for each phase of the three phase system. Rheostats can be collectively set with even resistance values to provide balanced load across all phases, or unevenly set to demonstrate uneven loading characteristics on an electrical generation system.



Industrial grade sensors measure and send system parameters to an integrated National Instruments™ digital data acquisition system. This system provides proper signals directly to control panel meters and through a USB connection for real time display on the provided laptop computer. The virtual instrument, created with LabVIEW™, offers real time display and interactive operator control features. Run data can be recorded for playback or follow-on analysis. The data acquisition software is user configurable and all source code is open.

Disassembled All-Alloy Planetary Gear Box

All components are pre-mounted on a portable rolling chassis allowing the entire system to be conveniently moved for use and storage. Metal surfaces are stainless steel, anodized or powder coated for durability and ease of maintenance. Controls are in plain view and intuitively arranged for ease of use. A comprehensive Operator's Manual details all aspects of system operation. Complete technical and service information allows students, educators and technicians to gain a thorough understanding of system design, operation and construction. Summary operating checklists allow rapid mastery of system operation. Safety instructions address all operating conditions.

*Wind*Lab™ Wind Turbine Power System

Experimental / Demonstrational Opportunities

*Wind*Lab™ enables students and researchers to readily conduct in-depth experimentation and analysis of wind turbine electric power generation.

The existing rotor airfoil blades can be easily removed, allowing alternative airfoil rotor blades to be designed and installed for performance comparison testing. **Aeronautical** and **structural engineering students** will find this *Wind*Lab™ aspect alone to be challenging and highly educational.

Control engineering students will gain valuable knowledge and hands-on experience beyond the classroom with the programmable variable speed wind fan that can be operated manually or programmed to automate specific wind profiles. Various wind scenarios can be programmed and actually run to demonstrate/ determine wind turbine power generation performance. The programmable wind speed capabilities can even be used to run actual wind data profiles from proposed full-scale wind turbine sites to help determine site potential.

Electrical engineering students will especially appreciate the purpose-built three-phase electric generator on *Wind*Lab™. With adjustable resistive loading on each phase, users can experiment with the affects of unbalanced loading at various generation speeds, while experiencing the hands-on operation of a true three-phase electric power generation system.

Mechanical engineering students will gain knowledge and experience with the on-board rotor to generator speed amplification gear box.

The integrated data acquisition system records and displays data in real time for enhanced experimentation and analysis of all aspects of the *Wind*Lab™ System.

The very capable, open-ended design of *Wind*Lab™ allows for a multitude of educational and research possibilities including;

- Basic understanding of wind turbine power generation system operation
- Aerodynamic performance studies of wind turbine blade airfoils
- Gearbox design and operation analysis
- Three phase electrical generator operation and analysis
- Electrical power production in steady state wind conditions
- Unsteady wind/gusting conditions affect on power production
- Balanced/unbalanced loading affects on wind turbine performance
- Programmable wind profiles for performance studies
- Frequency control considerations
- Experimental and data acquisition technique
- Discussion topic: Considerations for stand-alone energy storage systems
- Discussion topic: Considerations for power grid integration
- Discussion topic: Considerations for wind farm coordination
- Discussion topic: Considerations for wind turbine maintenance
- Discussion topic: Power factor for an inductive load

Airfoil built with rapid prototype technology for comparative testing

Details

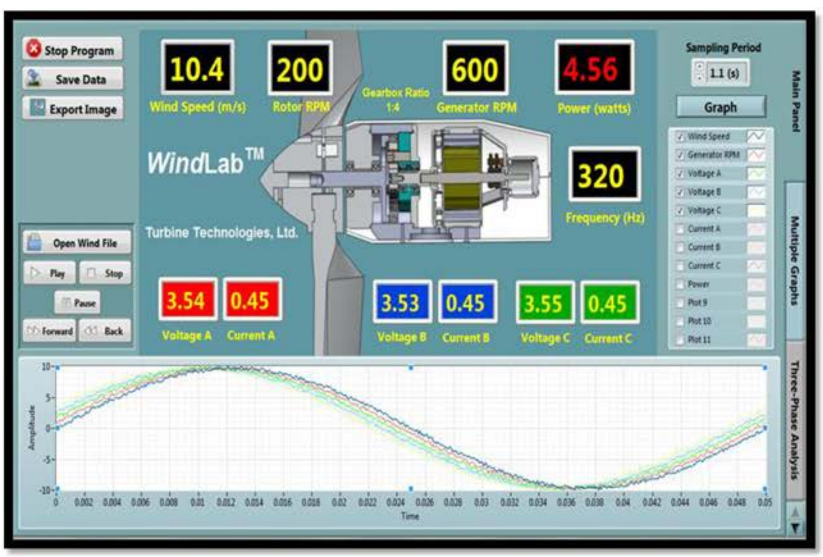
Dimensions
*Wind*Lab™: 67 w x 45 d x 76 h inches (170 w x 114 d x 193 h cm)
As Shipped: 70 w x 48 d x 82 h inches (178 w x 122 d x 208 h cm)

Weight
*Wind*Lab™: 712 lbs (323 kg)
As Shipped: 792 lbs (359 kg)

Instrumentation
Data Acquisition System:
National Instruments™ Hardware
32 Analog IN - 16 Digital IN/OUT - 2 Frequency/Counter Channels
Windows Laptop Computer - all Software Loaded and Pre-calibrated
Single Cable USB to PC Connection
Custom Virtual Instrument Display with Configurable Data Output
Installed Data Acquisition Sensors / Channels
Wind Speed
Wind Turbine Rotor RPM
Generator RPM
Generator Frequency
Generator Voltage for Each Phase
Current Draw for Each Phase
Total Power Output
Control Panel Mounted Displays/Controls:
Wind Speed
Turbine RPM
Voltage (3 total, one for each phase)
Current (3 total, one for each phase)
Load Rheostats (3 total, one for each phase)

Operating Conditions / Limitations
Wind Fan: Limited to 8.2 Amp Electrical Current Draw (fuse protected)
Generator: 7.5 Volts, 0.25 Amp, 3.25 Watts (Limited for Safety)

Operating Requirements
Typical Laboratory or Classroom Setting
Power: 208V single-phase 50/60Hz fused at 15 amp



Screen Shot of Included Virtual Instrument Panel

Purchase Specifications

- A wind turbine electric power plant designed for engineering education and research.
- A programmable wind fan and scale wind turbine mounted in a rigid, mobile wind tunnel cabinet.
- Wind fan to be driven by on-board, variable frequency drive with panel mounted speed controller.
- Wind turbine to be industry-standard three blade horizontal axis configuration with adjustable/replaceable blades.
- Wind turbine to drive planetary gear configuration step-up gear box.
- Generator to consist of a three phase, DC excited 8 pole rotor, eight pole three phase stator, with alternating current output.
- Unit to include operator panel-mounted generator voltage and current meters for each power phase.
- Load to be supplied by three operator panel-mounted rheostats, adjusted equally for balanced load, or unequally for unbalanced load scenarios.
- To be supplied with a USB based digital data acquisition system complete with computer and user configurable data acquisition software capable of measuring, recording and displaying analog, digital and frequency signals, including: Wind Speed, Turbine Rotor Speed, Generator RPM, Voltage, Current, Power and Frequency.
- Equipped with calibrated transducers capable of measuring all elements required for data acquisition system.
- All metal surfaces to be stainless steel, anodized or powder coated to promote durability and wear resistance.
- Provided with a comprehensive Operator's Manual with design, operation and construction information.
- Provided with summary operating checklists and safety instructions for all operating conditions.
- To be covered by a free two year warranty.

RankineCycler™ Steam Turbine Power System

A complete miniature vapor power system illustrating the concepts of thermodynamic cycles, mass and energy conservation and electrical power generation.

Product Summary

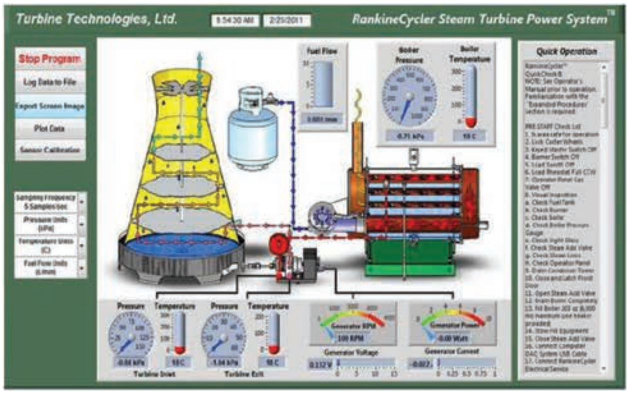
- Portable Educational Vapor Power System
- ASME Certified Power Boiler and Power Piping
- National Instruments™ Data Acquisition System with On-board Sensors
- LabVIEW™ Generated, User Configurable, Real Time Computer Data Display
- Modern Real World Steam Turbine Design
- Simple to Operate with Automatic Safety Features Throughout
- Complete Thermodynamic Teaching Solution
- Designed to Meet ABET Criterion 4 and 6 Objectives
- Complete, Turn-Key System - Ready to Start Teaching upon Delivery
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

A complete steam power plant designed for engineering education. All major components of a full-scale power plant are replicated for hands on study. Although miniature in scale, students are able to experience the full scope of real world thermodynamic principles.

The purpose built tube-type boiler is certified as a Section 1 Power Boiler (“S” Stamp) by the American Society of Mechanical Engineers (ASME). The boiler is also registered as a certified power boiler with the National Board of Boiler and Pressure Vessel Inspectors (NB). It features multiple safety devices for burner operation and system pressure, including; automatic over-pressure relief valve, automatic low-water level cut-off sensor and manual system blow-down valve. A sealed sight glass indicates boiler water level. A steam powered axial flow turbine drives a generator producing alternating current and rectified direct current at the output. The steam exhausts into a condenser tower where it returns to its original liquid state.

All components are pre-mounted on a portable rolling chassis allowing the entire system to be conveniently moved for use and storage. Metal surfaces are stainless steel, anodized or powder coated for durability and ease of maintenance. Controls are in plain view and intuitively arranged for ease of use. A USB connected National Instruments™ digital data acquisition system is fully integrated and pre-calibrated. Industrial grade sensors measure system parameters for a LabVIEW™ generated real time virtual instrument display on the provided laptop computer. Data can be recorded for playback or follow on analysis. Data acquisition software is user configurable without programming. A graduated beaker and boiler fill-drain system are used to accurately measure the feedwater amount before and after use as well as the total condensate collected. A comprehensive Operator’s Manual details all aspects of system operation. Complete technical and service information allows students, educators and technicians to gain a thorough understanding of system design, operation and construction.



Details

Dimensions	RankineCycler™: 58 x 48 x 30 inches (148 x 122 x 77 cm) As Shipped: 64 x 55 x 33 inches (164 x 141 x 84 cm)
Weight	RankineCycler™: 400 lbs (182kg) As Shipped: 480 lbs (216kg)
Instrumentation	Digital: National Instruments™ Data Acquisition System LabVIEW™ Data Acquisition Software with Configurable Output Windows™ Laptop Computer for On-Screen Data Display Single Cable USB to PC Connection 20 Analog IN - 16 Digital IN/OUT - 4 Frequency/Pulse IN Sensors (Pre installed and Calibrated) Boiler Temperature and Pressure Turbine Inlet Temperature and Pressure Turbine Exit Temperature and Pressure Turbine RPM Fuel Flow Generator Voltage Output & Current Draw Analog: Boiler Pressure, Generator Voltage & Current Draw
Limitations	Boiler: Pressure 120 psi (827 kPa), Temperature 482 F (250 C) Generator: 15.0 Volts, 1.0 Amp (Total Load of 15.0 Watts)
Requirements	Typical Laboratory or Classroom Setting Power: 120V single-phase 50/60Hz (220V upon request) Fuel: Liquid Propane

Experimental Opportunities

- Energy relationships and the First Law of Thermodynamics.
- Cycle analysis and the Second Law of Thermodynamics.
- Control volume analysis.
- Entropy analysis.
- Isentropic analysis and the study of turbine/nozzle efficiency.
- Heat transfer analysis and the study of boiler efficiency.
- Combustion processes.
- Vapor power system fundamentals.
- Electric power generation.
- Experimental & data acquisition technique.

Purchase Specifications

- A steam electric power plant designed for engineering education.
- Consisting of a fossil-fueled boiler, steam turbine and condenser tower mounted on a rigid, mobile frame.
- ASME Section 1 Certified Power Boiler of a tube-type, flame-through design with access door to view the inner workings.
- Boiler equipped with an over-pressure relief valve, automatic low water level shut-down and manual blow down valve.
- Steam rate adjustable through a steam admission valve, regulating turbine speed and power output.
- Axial flow turbine used to drive an alternating current generator.
- Generator output to be rectified allowing the output of direct current.
- To be supplied with a USB based digital data acquisition system complete with computer and user configurable data acquisition software capable of measuring and recording analog, digital and frequency signals.
- Equipped with calibrated transducers and thermocouples capable of measuring boiler temperature and pressure, turbine inlet and exit temperature and pressure, turbine RPM, fuel flow rate and generator load, voltage and current.
- All metal surfaces to be stainless steel, anodized or powder coated to promote durability and wear resistance.
- Provided with a comprehensive Operator’s Manual with design, operation and construction information.
- Provided with summary operating checklists for all operating conditions.
- Provided with safety instructions to address all operating conditions.
- To be covered by a free two year warranty.

PumpLab™

A fully self-contained fluid flow laboratory enabling a range of study from introductory fluid mechanics through advanced fluid machinery analysis.

Product Summary

- Mobile Test Set for the Complete Exploration of Flow and Fluid Machinery Fundamentals
- Ideal for Both Academic Education and Industrial Training
- Fully Instrumented for Flow, Head, Power and Efficiency Analysis
- Clear Fluid Circuitry Reveals All Flow and Cavitation Phenomena
- Integrated Digital Motor Controller Displays Pump RPM, Current and Torque Values
- Complete with Quick Change Straight, Forward and Backward Curved Impellers
- *DigiDAQ™* Data Acquisition System Utilizing USB Technology
- User Configurable Real Time Computer Data Display
- Designed to Meet ABET Criterion 4 and 6 Objectives
- Supplied with a Comprehensive Operator's Manual, Checklists and Safety Instructions
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

A self-contained fluid flow laboratory designed for introductory and advanced fluid mechanics study. Basic fluids concepts involving energy and mass conservation, internal flow, the Bernoulli principal and Reynolds number are readily studied. Experimental investigation into advanced topics relating momentum, the Euler equation and fluid machinery analysis are also possible. Purely technical subjects regarding pump operation, performance analysis, piping systems and seal technology are immediately demonstrated and explored. Maximizing the educational impact of textbook direct examples, the PumpLab™ is suitable for a wide range of academic settings. From secondary through university and technical universities, the relationship between the theoretical and practical is clearly illustrated through experimentation with the PumpLab™.

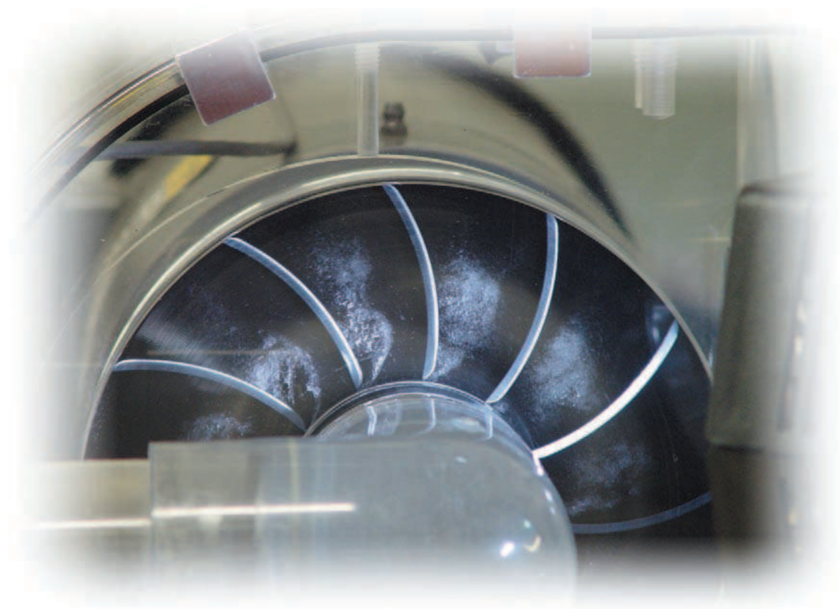
The universal centrifugal pump forms the core of the PumpLab™ Centrifugal Flow System. Used throughout industry, the centrifugal pump is an effective way to introduce both theoretical and practical fluid machinery concepts. Featuring the industry's only clear view pump housing, student understanding is maximized through direct observation of the various pump components. The pump housing, inlet, outlet, diffusion volute, impeller, shaft seals and drive coupling are all visible during system operation.

Straight, forward and backward curved impellers are provided to fully illustrate the effects of pump geometry on head and volume flow rate relationships. The various impellers can be interchanged with minimal effort and virtually no system downtime. Unique to the PumpLab™ is the availability of custom manufactured impellers. Low cost blanks and custom finished impellers are available to meet the needs of engineering classes with student design and project requirements. Direct access to the impellers and the ability to create new designs aids in student understanding of velocity diagram analysis and provides a foundation for advanced turbomachinery study.

Pump rotation is accomplished through a state of the art computerized vector drive. This programmable controller allows an infinite array of pump control schemes to be explored including variable-speed and constant torque operation. Considerably more versatile than a fixed speed motor, the variable-speed feature allows experimentation into high efficiency electronic fluid flow rate control. Concepts of power management, energy conservation and cost savings in the context of pumps and pumping systems can be examined with regard to real world needs and modern industry trends.

Water enters the pump through an instrumented test section offering expandability and operator customization. Exit flow passes through a transparent flow rotometer providing qualitative and digital indication of flow speed. Both the inlet and exit sides of the pump are equipped with valving to vary system load and head as well as to effect and control cavitation onset and propagation. The included strobe light coupled with the clear view pump housing makes cavitation and boundry layer phenomena dramatically apparent. All flow originates and ends in the fluid supply tank. Once filled, this tank requires no outside plumbing to maintain operation. The size and proximity of the supply tank lends itself to additional experimentation involving fluid statics and buoyancy.

All system components are pre-mounted on a rigid steel chassis equipped with rolling castors for portability and ease of storage. System piping is high-strength PVC or acrylic. The pump housing, rotometer and test section areas are computer numerically controlled finished machined and polished to minimize optical distortion. Metal surfaces are stainless steel, anodized or powder coated for durability and ease of maintenance. The water supply tank is integral to the unit and completely corrosion proof. All pump and piping system components are in plain view for instant identification, access and observation. Pump impellers and the provided support tools are securely stored and displayed in the integrated front cabinet. System controls are intuitive and conveniently located on the front panel. A keyed master switch is standard and provides secure control of system usage. A pump prime switch is used to conveniently operate the built in pump priming system. The motor control keypad and display allows direct access to all pump drive motor functions and indicates key motor variables.



A USB connected digital data acquisition system is fully integrated and precalibrated. Industrial grade sensors measure system parameters for real time display on the provided computer. Data can be recorded for playback or follow on analysis. Data acquisition software is user configurable without programming.

A comprehensive Operator's Manual details all aspects of system operation. Complete technical and service information allows students, educators and technicians to gain a thorough understanding of system design, operation and construction. Summary operating checklists allow rapid mastery of system operation. Safety instructions address all operating conditions.

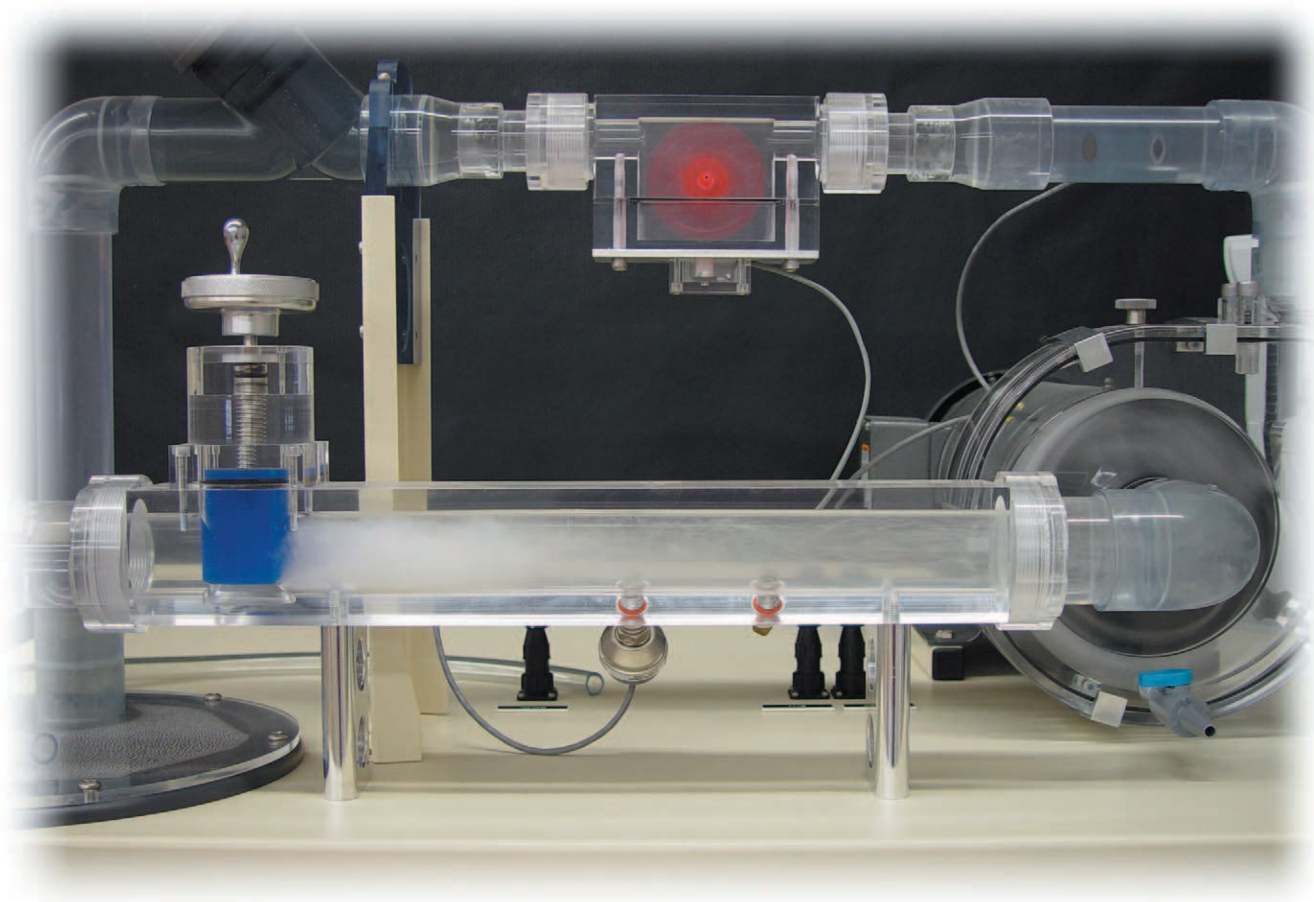
Experimental Opportunities

Numerous experimental and research opportunities are available and readily conducted with the PumpLab™ Centrifugal Flow System. The installed pressure and flow sensors allow basic experimentation relating to typical secondary physics and undergraduate fluid dynamics courses. Immediate access to the three common pump impeller types permits detailed analysis and experimental verification of energy, momentum and fluid machinery type problems. With the advanced vector drive system, concepts concerning efficiency and power conservation are easily explored. Visual vaporization bubbles help in the understanding and correlation of cavitation phenomena. Standard courses in engineering thermodynamics and fluid mechanics benefit from textbook direct examples conducted and measured in real time. The limitations of theoretical models and the variability of experimental technique can be experienced first hand. In addition to academics, the PumpLab™ is ideally suited for general pump and flow system familiarization as well as advanced practical studies for the technical and vocational student.

Illustrative examples of typical pump performance computations and exercises ~

With measured values of pump inlet and outlet pressure, flow rate, flow areas, impeller geometry, motor torque, RPM, current draw and power, determine:

- Turbomachinery Analysis - angular momentum, Euler Turbomachine equation, velocity polygon analysis and idealized centrifugal pump performance prediction
- Pump Characteristics - actual head, power required and efficiency at various flow rates / pump speeds
- Dimensional Analysis and Specific Speeds - determination of coefficients for pump selection, modeling and scaling problems
- Similarity and Affinity Analysis - design extrapolation and performance prediction from measured data
- Cavitation Analysis - quantifying various head values to predict, verify and measure parameters associated with the onset and propagation of cavitation phenomena
- Pump System Analysis - performance analysis at various simulated system heads for determination of pump and system operating points
- Energy Conservation - varying pump speed and system operating points to achieve cost savings



Details

Dimensions

PumpLab™:	71 x 48 x 29 inches (180 x 122 x 74 cm)
As Shipped:	81 x 55 x 33 inches (206 x 140 x 84 cm)

Weight

PumpLab™:	455 lbs (206 kg)
As Shipped:	535 lbs (243 kg)

Instrumentation

Digital: High Speed Data Acquisition System
Data Acquisition Software with Configurable Data Output
Windows XP Computer for On-Screen Data Display
Single Cable *DigiDAQ™* USB to PC Connection
20 Analog IN ~ 16 Digital IN/OUT ~ 4 Frequency/Pulse IN
Sensors (Preinstalled and Calibrated)

- Pump Inlet Pressure
- Pump Exit Pressure
- Flow Rate
- Pump Torque
- Pump RPM

Provided Operational Accessories

Three Impellers

Straight Impeller ~ $ß_{IN}$ 90˚ - $ß_{OUT}$ 90˚
Forward-Curved Impeller ~ $ß_{IN}$ 90˚ - $ß_{OUT}$ 115˚
Backward-Curved Impeller ~ $ß_{IN}$ 60˚ - $ß_{OUT}$ 20˚ (with splitter vanes)
Impeller Diameter, Outer 6.500" (16.51 cm) Inner 2.225" (5.65 cm)
Impeller Blade Height, Outer 0.135" (0.34 cm) Inner 0.312" (0.79 cm)

Stroboscope ~ adjustable from 0 to 3000 fps
Impeller Change Tool
Prime/ Drain T-Handle

Operating Conditions / Limitations

Main Pump and Supply Tank

Maximum Flow Rate:	40 GPM (151 lpm)
Maximum Head:	40 ft (12 mtrs)
Tank Capacity:	20 Gallons (76 ltrs)

Main Pump Motor

Maximum RPM	1725
Shaft Power	3.0 HP (2.2 kW)
Current	8.2 Amps
Frame Style	JM

Auxiliary Prime / Drain Pump

Maximum Flow Rate:	5 GPM (19 lpm)

Operating Requirements

Typical Laboratory or Classroom Setting Power:
220V single-phase 60Hz

Purchase Specifications

- A self-contained, mobile centrifugal flow system designed for engineering education.
- Consisting of a centrifugal pump, computer controlled motor, flow rotometer, instrumented test section, pump inlet and exit valving, cavitation viewing stroboscope and integrated reservoir supply tank requiring no external water source.
- Drive motor to be infinitely adjustable via computer controller with ability to regulate pump speed through torque, current or RPM measurement.
- Transparent pump housing to reveal inlet, outlet, diffusion volute, impeller, shaft seals and drive coupling during system operation.
- All flow circuit components to be transparent and mounted in clear view of operator.
- Supplied with straight, forward and backward curved impellers and necessary tools to rapidly remove and replace.
- Manufacture to make available blank and machined impellers at additional cost.
- To be supplied with a USB based digital data acquisition system complete with computer and user configurable data acquisition software capable of measuring and recording analog, digital and frequency signals.
- Equipped with calibrated transducers capable of measuring pump inlet and exit pressure, system flow rate, motor torque and RPM.
- All metal surfaces to be stainless steel, anodized or powder coated to promote durability and wear resistance.
- Provided with a comprehensive Operator's Manual with design, operation and construction information.
- Provided with summary operating checklists for all operating conditions.
- Provided with safety instructions to address all operating conditions.
- To be covered by a free two year warranty.

New Feature!

An integrated programmable controller with system pressure and flow feedback loops, along with PID gain application, can now be applied to a wide variety of fluid process flow control scenarios.

Product Summary

- Integrated Variable Frequency Drive with Programmable Control Keypad
- USB Computer DAQ Screen with Active System Controls/Programming Functions
- Integrated Pressure and Flow Control Feedback Loops
- Integrated Process Set Points
- Integrated Proportional, Integral and Derivative (PID) Gain Settings
- Real Time Data Plot Display and Run-Time Data Recording
- Included Sample Lab Procedure

Description

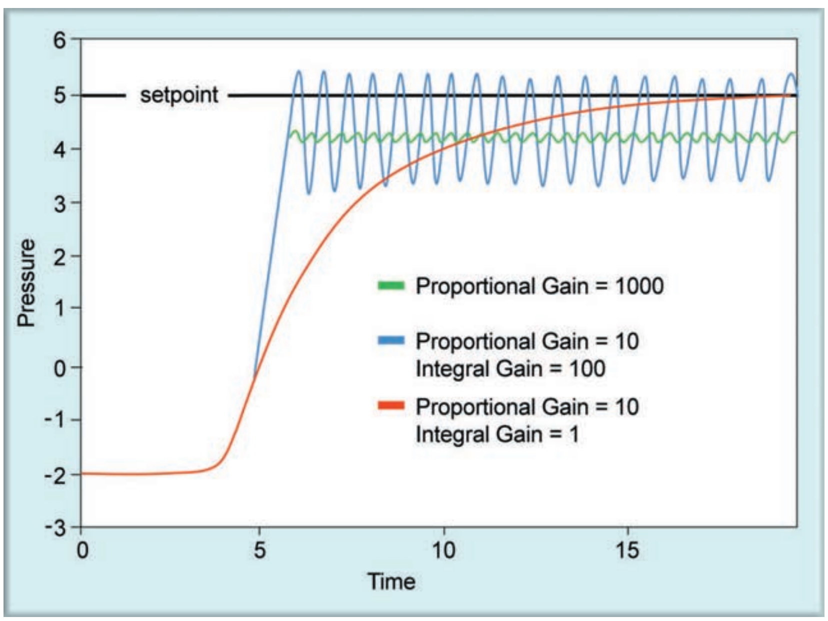
Centrifugal pumps are used extensively in industry to direct the flow of fluids for countless process requirements. Controlling the flow process is typically handled by a programmable Variable Frequency Drive (VFD). VFDs can be programmed to vary the control speed of the pump motor to allow the pump to meet the system fluid flow/pressure requirements. They can also be part of a large control scheme where many pumps are controlled and scheduled automatically to produce a desired result.

Feedback loops are typically used in Programmable Logic Control (PLC) to provide information to the VFD regarding adjustments that need to be made to the pump ramp-up speed, operating speed, and ramp-down speed. The operational performace programming driven by Feedback Loops is fine-tuned through the application of gain.

The PumpLab™ Process Control System features a programmable VFD that can be used to develop control scenarios for your pump. It also features dedicated feedback loops from pressure and flow transducers, which allow programming of specific process control scenarios. Proportional, Integral and Derivative (PID) gain capabilities are also integrated for tuning control response.

An included sample lab procedure offers programmable process control scenario exercises to quickly familiarize the operator with this aspect of the PumpLab™. The sample lab procedure is actually all-encompassing; it starts with PumpLab™ in the Pump Mode and teaches operators how to develop centrifugal pumping performance curves, using the supplied pump impeller profiles. This pump performance information can then be applied to countless fluid process control scenarios that can be derived and tested in PumpLab™ Process Control Mode.

Process development and control are disciplines many practicing engineers become involved with. Having a good foundation of pumping and process control education, along with hands-on training, will be extremely valuable for designing/expanding effective pumping process systems that get results.



View real-time gain response to user-entered flow & pressure set points

Program Variable Frequency Drive via keypad or interactive software

Experimental Opportunities

Programmable Process Control is a significant added feature to the original PumpLab™ Centrifugal Flow Educational System. It enables students to take the centrifugal pump education derived from using the system in pump mode and apply it to fluid process control scenarios. This whole process becomes very valuable in managing and optimizing fluid processing. Since pumping is one of the major energy consumers, it is important to understand pumping and process control to optimize the results for a given amount of electrical energy consumption.

- Define process parameters.
- Develop feedback loop protocol.
- Fine-tune system response with gain.
- Utilize developed pump curves for process performance requirements.
- Develop custom impeller profiles to meet specific process requirements.

Purchase Specifications

- LabVIEW™ interactive process control virtual instrument panel with real time sensor performance monitoring.
- Baldor™ H2 industrial programmable Variable Frequency Drive (VFD).
- Built-in process control programmable software.
- Integrated data acquisition system.
- Integrated Process Control Logic circuit.
- Built-in pressure and flow feedback circuits.
- System fully assembled, tested and ready to operate.
- Detailed sample lab procedure included.

TrueStructures ™

Airfoil Structures Lab

A fully integrated structures laboratory utilizing actual aerospace components for a real - world understanding of structural behavior.

Product Summary

- Compact Structures Laboratory Employing Actual Aerospace Components
- Interchangeable Test Specimens Include Beam, Tube and Wing Section
- Infinitely Variable Point Loading System to Apply Bending and Torsional Moments
- Integrated Load Cell Provides Direct Indication of Actual Applied Load
- Array of Preinstalled Strain Gauges to Measure Skin, Web and Beam Stresses
- Strain Bridge Controller displays Strain Gauge Voltages and Applied Load
- Software Tool Converts Measured Voltages to Engineering Strains
- Visual Scales Provide Quick Indication of Test Specimen Deflection while Under Load
- Extensive Sample Lab with Aero, Mechanical and Civil Engineering Applications
- Designed to Meet ABET Criterion 4 and 6 Objectives
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

TrueStructures is a complete structural analysis laboratory. Simple and complex bending, shear, and torsion are progressively demonstrated utilizing a beam, a tube and a complete aircraft airfoil structure.

The TrueStructures Lab is ready for immediate usage upon uncrating. A powder coated main support frame is made from structural steel tubing and mounted on rolling castors for mobility. The entire lab is sized to fit through any standard interior door.

A multi-lesson laboratory procedure is provided to illustrate common usage of the TrueStructures lab. Solid models are also included to show the internal wing structure. The solid models, laboratory procedures and strain calculation program are included on CD-ROM.

Industry standard linear and rosette foil strain gauges are strategically mounted on all test components to allow gathering of structural strain data under various loading conditions. The custom manufactured Strain Bridge Controller manages strain gauge excitation and digitally displays the selected strain voltage. Each individual strain gauge is switch-selectable. A simple software application allows easy conversion between measured strain voltages and actual engineering strain. A separate digital meter displays the applied load at all times. System load and selectable strain gauge voltages are available as outputs from the Strain Bridge Controller for reading by external data acquisition or other measurement systems.

Basic structural analysis can be studied with the readily interchangeable simple beam and tube structures. Unlimited opportunities exist with typical structures problems as well as the real world issues associated with experiment design, fundamental transducer concepts (strain gauges) and measurement noise. Provided lab projects include strain gauge fundamentals, applied loads, component section and material properties, principal and combined stresses, beam and torsional loading, shear flow and displacement.

The TrueStructures Lab features an actual aircraft horizontal stabilizer. This lifting surface is typical of that found on civil and military aircraft where stressed skin construction is used. This "wing" structure is made up of an all aluminum outer skin, two span wise webbed main spars and a set of chord-wise main and nose ribs. The entire assembly is fastened together using riveted construction.

The wing's main spar is affixed in aerospace fashion to a root fitting similar to a wing-fuselage structural joint. A mechanical jackscrew mechanism applies an infinitely variable point load to the wing tip. The point load can be positioned to place the specimen in pure bending, pure torsion, or combination loading. A precision load cell is mounted at the loading point that allows a direct readout of the applied force. Multiple uni-axial and rosette strain gages are strategically mounted throughout the wing to measure the resulting strain values.

A free, two year warranty is provided on the entire TrueStructures system.

Details

Instrumentation

Strain Bridge Controller:
- Wheatstone Bridge configuration, 12-channels individually selectable
- Digital display of strain voltages
- 350 Ohm dummy gauges ≈ 2.09 Gauge Factor
- Self contained 15-volt strain gauge exitation supply

Applied Load Indication:
- 0-100 lbs Button Type Load Cell
- Digital display of applied load in lbs or kg

Analog Output
- Strain Gauge: 0-10V proportional to strain voltage, channel selectable
- Applied Load: 0-10V proportional to load cell output

Dimensions

TrueStructures™: 65L x 36W x 33H inches (165 x 91 x 84 cm)
As Shipped: 72L x 48W x 45H inches (183 x 122 x 114 cm)

Weight TrueStructures™: 250 lbs (113 kg) As Shipped: 325 lbs (147 kg)

Experimental Opportunities

- Fundamental problems associated with statics and strength of materials.
- Basic structures concepts of bending, shear and torsion.
- Advanced problems with shear flow, combined loads and fittings.
- Material shapes, section properties and their effects on structural efficiency.
- Problems with loading, deflection and the stress & strain relationship.
- Usage of strain gauges and support equipment for experimental stress determination.
- Aerospace, civil and mechanical structures analysis and testing.
- Design of experiments and data acquisition technique.

Purchase Specifications

- A multi-use structures laboratory designed for engineering education.
- Utilizes interchangeable structural shapes that can be loaded in bending, torsion or combinations thereof.
- Aerospace test article to be of an actual aircraft-lifting surface.
- Provided with multi-lesson laboratory procedures.
- To Include solid models of all test sections.
- Equipped with an infinitely variable, manually adjusted loading apparatus.
- Loading mechanism to be equipped with a fail safe over load device.
- Button type load cell installed at the point of load and connected to a digital display to indicate applied load/force in pounds or kilograms.
- Steel tape scale adjacent to the test article for the observation of deflection under load.
- All test articles to be instrumented with industry standard, foil-type strain gauges.
- Supplied with a 12-channel Strain Bridge Controller that powers the strain gauge circuit, is switch selectable between strain gauges and connected to a digital display to indicate selected strain gauge voltage.
- Designed with an "open architecture" that allows additional strain gauges on existing or user test articles.
- Frame to be manufactured from structural steel and finish powder coated as appropriate.
- Frame assembly equipped with lockable rolling castors.
- To be covered by a free two year warranty.

MiniLab™

Gas Turbine Power System

A fully integrated jet propulsion laboratory ideally suited for both introductory and advanced study of thermodynamic and operating principles of gas turbine power plants.

Product Summary

- Complete Educational Jet Propulsion Power System
- Suitable for Secondary, University, Technical and Military Education and Training
- Purpose Built Gas Turbine Engine Designed and Manufactured to Aerospace Standards
- Integrated Test Cell ~ Requires No Facilities Modification
- All Key Engine Stations Fully Instrumented for Temperature and Pressure Measurement
- Most Stable and Reliable Operation of any Engine in Size and Thrust Class
- Fully Instrumented Operator Control Panel Featuring OneTouch™ Automatic Start
- *DigiDAQ™* Data Acquisition System Utilizing USB Technology
- User Configurable Real Time Computer Data Display
- Designed to Meet ABET Criterion 4 and 6 Objectives
- Supplied with a Comprehensive Operator's Manual, Checklists and Safety Instructions
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

A complete gas turbine power plant designed for engineering, technical and military education as well as advanced research and study. The core gas-generator is representative of all major gas turbine types and permits ready textbook direct analysis of air equivalent Brayton and Gas Turbine cycles. Students are able to apply fluids, thermodynamic, combustion and gas turbine theory to the operation of an actual engine. Laboratory experience gained with the MiniLab™ is directly applicable to aero and marine turbine propulsion and industrial gas turbine applications.

The SR-30 Turbo-Jet engine is designed and manufactured by Turbine Technologies, LTD specifically for the MiniLab™ Gas Turbine Power System. The compact engine features a centrifugal flow compressor, reverse flow annular combustor and an axial flow turbine stage. The SR-30 follows the fundamental gas turbine cycle: Ambient air enters the engine through the bell shaped inlet. The air is then compressed, diffused and directed into the combustor can. Kerosene based fuel, introduced via six high-pressure atomization nozzles, is mixed with the compressed air and ignited. Heated combustion gas expands and accelerates through the vane guide ring causing the turbine to rotate. Useful work is extracted from this rotation as the turbine powers the compressor. The combustion gases are further accelerated through the thrust nozzle where the remaining heat energy is converted to kinetic energy in the form of jet thrust. The ejected gas returns to ambient atmospheric conditions thereby completing the thermodynamic cycle.

For safety and performance reasons, no off-the-shelf, former military or surplus components are used in any portion of the engine. All components are manufactured in-house to exacting specifications. Electronic controlled vacuum investment casting insures void and impurity free components. Computer numerically controlled machine centers maximize finished part accuracy. Individual component materials are selected based upon desired mechanical properties, durability and longevity. Combustor components and the vane guide ring utilize Inconel® 718 alloy. The integral bladed disk turbine wheel is manufactured from CMR 247 Super Alloy. All material is fully traceable and verified to possess the desired properties specific to the application. The completed engine undergoes rigorous final operational testing and inspection. Purpose built from the start, the SR-30 requires no questionable modifications prior to integration into the MiniLab™ Gas Turbine Power System.

The MiniLab™ cabinetry is composed of a rigid steel chassis mounted on rolling castors for portability and ease of storage, requiring no permanent facility modifications or additions. The SR-30 engine is securely mounted within the cabinet behind protective transparent polycarbonate shields affording the operator and observers clear, unimpeded viewing of the engine during operation. All engine accessories including fuel and oil pumps are located in the lower portion of the cabinet. No dedicated engine accessory drive is required, thereby eliminating the distraction of non-essential engine loading considerations in thermodynamic and performance analysis. Safe and reliable air starting provides for consistent and easy engine operation without the need for additional electric starters, complicated couplings, heavy cabling, high amperage current or auxiliary batteries. All fuel atomization is accomplished within the fuel control unit and adjacent nozzles. No gaseous fuels of any type are required for starting. A wide range of kerosene based or diesel blended fuels may be used without the need for any fuel preheating or conditioning.

A single button initiates automatic engine start. System parameters are monitored during all phases of engine operation by an electronic engine control unit. Any out-of-limit condition results in the safe shutdown of the engine. Fuel and oil levels are monitored continuously thereby eliminating the potential for damaged pumps due to dry operation. Engine speed is fully controllable. A liquid crystal display panel alerts the operator to any system faults. Total run time and cycle counts are digitally recorded. A single button, prominently marked and readily located safely shuts the system down.

Industrial grade sensors measure all key engine station parameters as well as overall system variables for real time display on the provided computer. Direct engine thrust is accurately measured through a pivoting bearing arrangement utilizing a calibrated load cell, eliminating problems inherent to linear bearings with critical alignment requirements. A USB connected digital data acquisition system is fully integrated and precalibrated. User configurable software allows the creation of custom data displays without the need for programming. Data can be recorded for playback or follow-on analysis. The full range of sensors allows calculations of fuel flow, thrust and pressure ratio to be compared directly to measured values.

Design, technical and manufacturing information and specifications are available for specific teaching and research requirements. Actual engine components and system parts are optionally available for use as teaching and training aids. As the original engine manufacturer, complete spares availability is guaranteed. A free, two year warranty is provided on the entire MiniLab™ system including the SR-30 engine. Additional service and support is available as necessary. On site operator training is available at additional cost.

A comprehensive Operator's Manual details all aspects of system operation. Summary operating checklists allow rapid mastery of MiniLab™ Gas Turbine Power System operation. Safety instructions address all operating conditions.

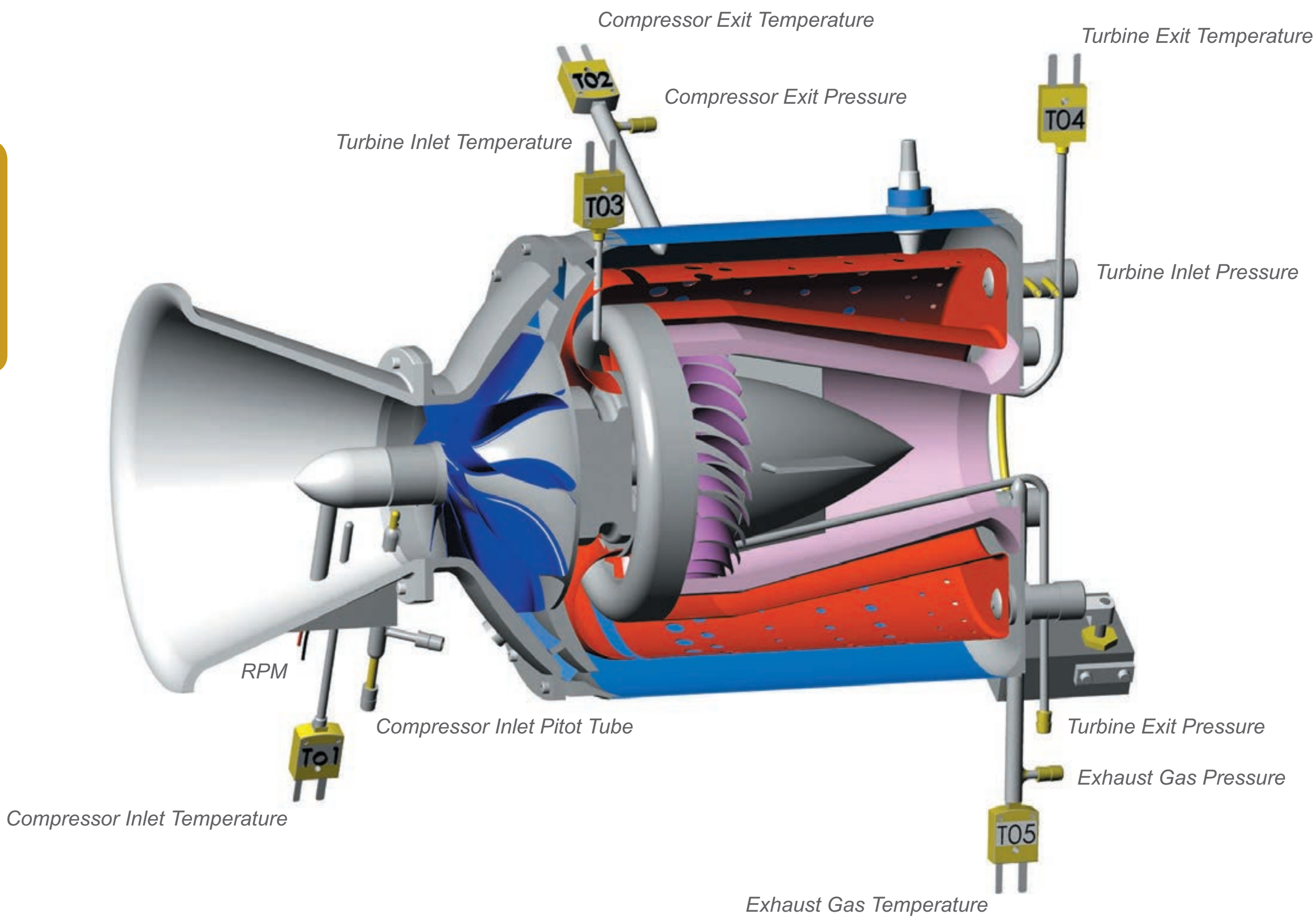
Experimental Opportunities

Experimental and research opportunities include scientific, engineering, thermodynamic and environmental investigations. With a wide array of sensors, experiments relating to secondary education physics and chemistry through graduate level fuels and combustion research are readily performed. Standard courses in engineering thermodynamics and fluid mechanics benefit from textbook direct examples conducted and measured in real time. The limitations of theoretical models and the variability of experimental technique can be experienced first hand. In addition to academics, the MiniLab™ is ideally suited for general gas turbine familiarization and jet engine operational training for aviation and military professionals.

Illustrative examples of Gas Turbine computations ~

With measured values of compressor inlet temperature and pressure, turbine inlet temperature and pressure, turbine exit temperature and pressure, fuel flow and inlet and exit areas, possible calculations include:

- Compressor Analysis - compressor pressure ratio, power required, rotational speed and compressor efficiency
- Turbine Analysis - work and power developed, expansion ratio and turbine efficiency
- Cycle / Brayton Type Analysis - mass flow rate, inlet and exit velocity, station temperature and pressures, combustion and thermal efficiency, specific fuel consumption and power / thrust developed
- Combustion Analysis - excess air and fuel-air ratio
- General Analysis - diffuser and nozzle performance and efficiency



Details

Dimensions

MiniLab™:	40 W x 42 D x 62 H inches (102 x 107 x 158 cm)
As Shipped:	48 W x 54 D x 70 H inches (122 x 137 x 178 cm)

Weight

MiniLab™:	460 lbs (208 kg)
As Shipped:	614 lbs (276 kg)

Instrumentation

Digital: High Speed Data Acquisition System

Data Acquisition Software with Configurable Data Output
Windows® XP Computer for On-Screen Data Display
Single Cable *DigiDAQ*™ USB to PC Connection
20 Analog IN - 16 Digital IN/OUT - 4 Frequency/Pulse IN
Sensors (Preinstalled and Calibrated)

- Compressor Inlet Temperature and Pressure (T1/P1)
- Compressor Exit Temperature and Pressure (T02/P02)
- Turbine Stage Inlet Temperature and Pressure (T03/P3)
- Turbine Stage Exit Temperature and Pressure (T04/P04)
- Thrust Nozzle Exit Temperature and Pressure (T05/P05)
- Fuel Flow
- Thrust
- Engine Rotational Speed (RPM)

Digital and Analog: As provided on the Operator Control Panel

- Digital Turbine Inlet Temperature (TIT)
- Digital Exhaust Gas Temperature (EGT)
- Digital Engine Rotational Speed (RPM)
- Analog Oil Pressure
- Analog Engine Pressure
- Analog Air Start Pressure

Operator Panel Controls

Master Switch, Keyed -	Secured control of equipment usage
Green Start Button, Push-	Initiates Engine Start, Multiple Functions
Red Stop Button, Push-	Initiates Engine Shutdown, Multiple Functions
T-Handled Power Lever -	Controls Engine RPM
Integral LCD Display -	Real Time System Status

Operating Conditions / Limitations

Design Maximum Thrust:	40 lbf (178 N)
Approved Fuels:	Jet A, A-1, B; JP-4, 5, 8; Kerosene, Diesel, Fuel Oil #1 or #2
Exhaust Gas Temperature:	1328˚ F (720˚ C)
Mass Flow:	1.1 lbs/s (0.5 kg/s)
Ignition System:	Air gap, high voltage capacitor discharge type hermetically sealed ignition coil and igniter plug
Compressor Type:	Single Stage Centrifugal (Radial Outflow)
Turbine Type:	Single Stage Axial Flow
Design Maximum RPM:	87,000
Engine Mount:	Pivot bearing support allowing direct thrust to be obtained by a load cell
Engine Compression Ratio:	3.4
Engine Pressure Ratio:	30.0
Specific Fuel Consumption:	1.2
Approved Oils:	MIL-PRF-23699F-STD
Engine Diameter:	6.8 inches (17 cm)
Engine Length:	10.8 inches (27 cm)

Operating Requirements

Typical Laboratory Setting

Power:	120V single-phase 60Hz (220V upon request)
Air:	Typically available 120PSI shop air

Purchase Specifications

- A complete gas-turbine power system to consist of an engine designed and manufactured for engineering education.
- Engine must utilize a centrifugal flow compressor, reverse flow annular combustor and an axial flow turbine stage.
- Engine to be of current manufacture and consisting of all new components.
- All engine components either vacuum investment cast or precision CNC machined.
- All high-heat components manufactured from 17-4 ph stainless steel, Inconel® 718 or CMR 247 Super Alloy.
- Traceable and verifiable material to be used throughout engine.
- All elements comprising the system to be contained in a rigid steel chassis mounted on rolling castors.
- All system metal surfaces to be stainless steel, anodized or powder coated to promote durability and wear resistance.
- Complete system not to require any permanent facility modifications or additions.
- Engine situated behind transparent protective shields allowing clear view during operation.
- Operator capable of manual control throughout entire range of operation.
- Operator panel to consist of digital TIT, EGT, and RPM indicators, analog oil pressure, engine pressure ratio, fuel pressure and air pressure gauges, keyed master, green start, red stop and T-handled power control lever.
- System to be equipped with calibrated transducers and thermocouples capable of measuring compressor inlet, compressor exit, turbine stage inlet, turbine stage exit and thrust nozzle exit temperature and pressures, fuel flow, thrust and engine compressor / turbine rotational speed.
- Engine thrust to be measured by a load cell permitting direct indication of thrust value.
- To be supplied with a USB based digital data acquisition system complete with computer and user configurable data acquisition software capable of measuring and recording analog, digital and frequency signals.
- Fully automatic engine start and operational health monitoring system provided with LCD status readout and cumulative runtime and cycle count.
- Representative engine components and technical data optionally available for teaching use and training aids.
- Manufacturer to guarantee spares availability and provide technical support services for core engine and power system.
- Provided with a comprehensive Operator's Manual.
- Provided with summary operating checklist for all operating conditions.
- Provided with safety instruction to address all operating conditions.
- To be covered by a free two year warranty.

TurboGen™ Gas Turbine Electrical Generation System

A complete turboshaft engine genset illustrating the concepts of electrical power generation, thermodynamic cycles and mass and energy conservation.

Product Summary

- Gas-Turbine-Driven Genset
- Portable, Self-Contained and Ready to Operate
- National Instruments™ DAQ System with Expandable LabVIEW™ Displays
- Complete Thermodynamic Teaching Solution
- Open-Ended Design to Meet ABET Criterion 3a,b,c,d,e,k and 4 Objectives
- Nothing More to Add or Buy - Ready to Start Teaching upon Delivery
- Supplied with a Comprehensive Operator's Manual, Checklists and Safety Instructions
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

A complete turboshaft engine genset instrumented for educational purposes. The compact jet engine gasifier core is representative of all major gas turbine types and entails an axial flow turbine stage, reverse flow annular combustor and radial flow compressor stage. This permits textbook direct analysis of the air equivalent Brayton Cycle. Students are able to apply fluids, thermodynamics, combustion and gas turbine theory to the operation of an actual engine.

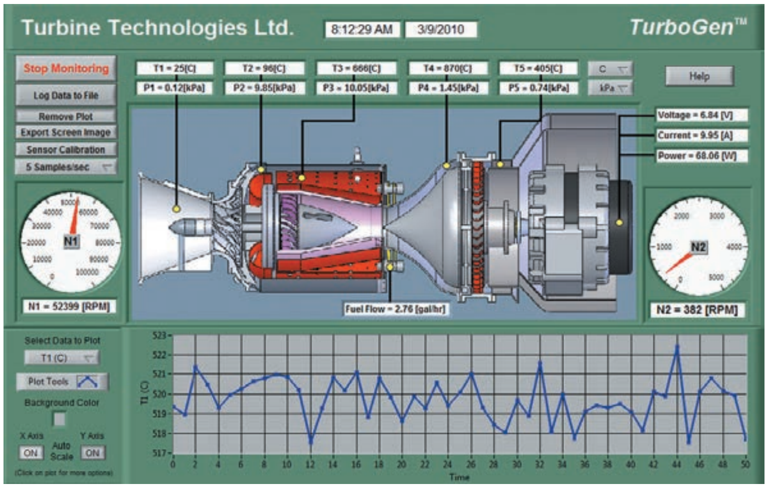
The electric power generation section features a thrust driven free power turbine directly coupled to a three phase liquid-cooled electric alternator. The generation circuit is base-loaded with an integrated fixed-value resistance module. An adjustable-rate excitation current controller allows wide-range alternator loading through the complete speed range of the generation system. The electrical power system can produce up to 14.4 volts, with a maximum rated power output of 2.1 kW. A jet thrust driven exhaust fan effectively expels heat and exhaust from the engine/generator compartment.

A fully automated engine start and health monitoring system is also included, which entails a Liquid Crystal Display status readout with a built-in cycle/hour meter.

Fifteen sensors report directly to an installed National Instruments™ DAQ platform, which entails customized LabVIEW™ displays (as depicted below). Data is configurable for output via numerous export options which include .txt and .csv file types.

The gas turbine generation system is purpose designed for this application. All components of the engine and bulk of the generation system are manufactured and assembled at TTL. This true OEM approach results in an affordable, ready to operate, supportable educational solution.

Data Acquisition & Gas Flow Path Screen Shot



Details

Dimensions	TurboGen™:	40 x 42 x 62 inches (102 x 107 x 158 cm)
	As Shipped:	48 x 54 x 70 inches (122 x 137 x 178 cm)
Weight	TurboGen™:	460 lbs (208kg) As Shipped: 614 lbs (276kg)
Instrumentation	Data Acquisition System with Configurable Data Output	
	Windows XP Laptop Computer for On-Screen USB Data Display	
Sensors	• Compressor Inlet & Exit Temperature and Pressure	
	• Turbine Inlet Temperature and Pressure	
	• Turbine Exit / Power Turbine Inlet Temperature and Pressure	
	• Power Turbine Exit Pressure and Temperature	
	• Fuel Flow	
	• Gasifier & Generator Rotational Speed (RPM)	
	• Generator Current & Power	
Generator Limits	Regulated Volts: 13.1 Volts	Maximum Current: 194 Amps
	Maximum Power: 2541 Watts	Maximum RPM: 5000
Gasifier Limits	Mass Flow: 1.1 lbs/s (0.5 kg/s)	Turbine Inlet Temp: 1328˚F (720˚C)
	Engine Speed:	87,000 RPM
Operating Requirements	Approved Fuels:	Jet A,A-1,B;JP-8;Kerosene, Diesel, Fuel Oil #1 or #2
	Approved Oil:	MIL-PRF-23699F-STD
	Power:	120V single-phase 60Hz (220V 50Hz upon request)
	Air Pressure:	120 PSI (827 KPa)

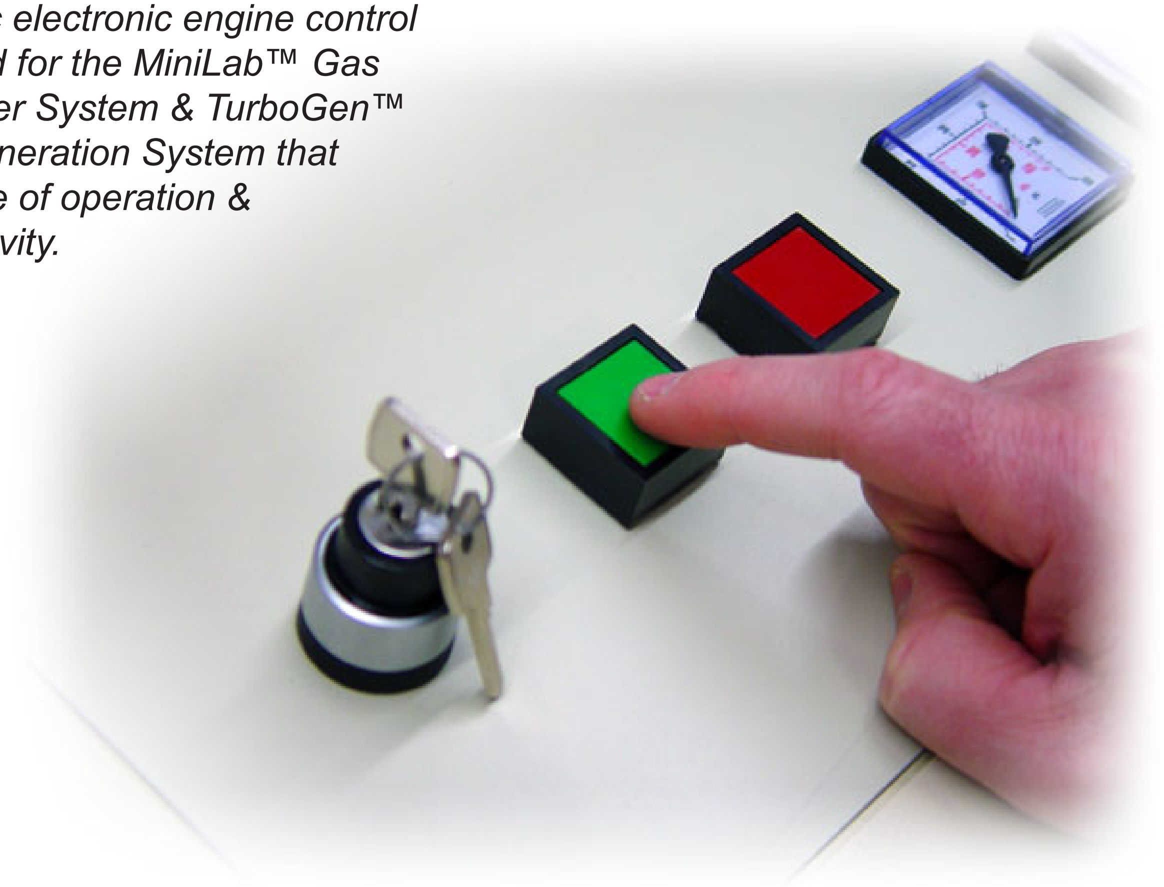
Experimental Opportunities

- Energy relationships and the First Law of Thermodynamics.
- Cycle analysis and the Second Law of Thermodynamics.
- Control volume analysis.
- Entropy and enthalpy analysis.
- Isentropic analysis.
- Electric power generation analysis.
- Cycle and component efficiency studies.
- FEA & CFD analysis via available component CAD models.
- Airfoil velocity vector diagram construction.
- Experimental and data acquisition technique.

Purchase Specifications

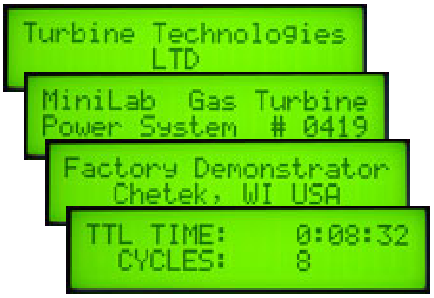
- A complete micro turbine genset to consist of an engine/generator combination designed and manufactured specifically for engineering education.
- Engine must utilize an axial flow turbine stage, a reverse flow annular combustor, a free power turbine stage and a centrifugal compressor stage.
- System to include a USB connected laptop computer interfaced with National Instruments™ hardware and customized LabVIEW™ VI displays.
- System sensor package to entail 15 data reading points to include compressor inlet temperature and pressure, compressor stage exit temperature and pressure, turbine inlet temperature and pressure, power turbine inlet temperature and pressure, power turbine exit temperature and pressure, fuel flow, engine core RPM, power turbine RPM, generator current and power.
- Engine to be of current manufacture and consisting of all new components.
- Traceable and verifiable material to be used throughout engine.
- All elements comprising the system to be contained in a rigid steel chassis mounted on rolling castors.
- Complete system not to require permanent facility modification or additions.
- Complete genset to be mounted behind transparent protective shields allowing clear view during operation.
- Fully automatic engine start and operational health monitoring system provided with LCD status readout and cumulative run-time cycle count.
- Representative engine components and technical data optionally available for teaching use and training aids.
- Manufacturer to guarantee spares availability and provide technical support services for core engine and power system.
- To be covered by a free two-year warranty.

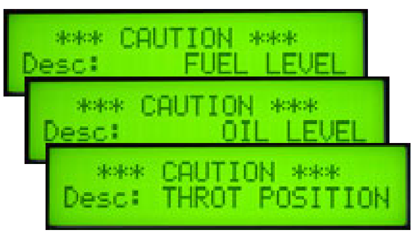
An automatic electronic engine control unit designed for the MiniLab™ Gas Turbine Power System & TurboGen™ Electrical Generation System that ensures ease of operation & engine longevity.



Product Summary

- Autostart System Reflects Aero, Marine and Industrial Turbine Engine Practice
- Fuel Introduction and Ignition Occurs at Optimal Engine RPM
- Electronic Monitoring Ensures Temperature and RPM Limitations Are Not Exceeded
- Operator Interface Displays N1%, TIT and EPR
- Total Engine Run-Time and Cycle Count Permanently Recorded
- System Alerts Operator to Low Fuel and Low Oil Conditions
- Exceeding Any Engine Limit Results in Immediate Engine Shutdown
- Engine is Manually Controllable Throughout Entire Operating Range
- Software Upgradeable to Allow Incorporation of Periodic Updates
- Automation Allows Operator to Focus on Educational or Research Activities
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA





Description

Turbine Technologies MiniLab™ Gas Turbine Power System and TurboGen™ Gas Turbine Electrical Generation System feature a fully autonomous computer controlled start and engine monitoring system. Purpose designed and specifically built for the SR-30 Gas Turbine Engine,the OneTouch™ system manages the engine start process and continuously monitors all subsequent engine operation. Should a critical engine parameter be exceeded, OneTouch™ immediately shuts the engine down and alerts the operator to the cause. OneTouch™ greatly simplifies engine operation and effectively frees the MiniLab™ operator to focus on instruction, demonstration and data gathering without compromising safety or engine health. With OneTouch™, virtually anyone can operate the MiniLab™ or TurboGen™ with confidence and assurance that the safest and most efficient means are employed during the starting and operation of the engine.

Two buttons and the traditional T-Handled Power Lever are all that is necessary to operate the MiniLab™ or TurboGen™ through the OneTouch™ system. A backlit LCD screen integral to the operator panel serves as the primary user interface. During normal operation, the LCD screen indicates all monitored engine parameters and provides a simple indication of system status. Should OneTouch™ command an engine shutdown, the cause for the shutdown will be displayed. Additional diagnostic and stored data retrieval functions are available through a combinatorial selection of the two buttons and power lever.

Operation with OneTouch™ is both intuitive and straightforward. A keyed master switch limits system operation to those that are authorized to do so. With the keyed switch on, power is immediately applied to OneTouch™. During system initialization, several screens are displayed that provide basic system information such as cumulative engine run-time and total engine start/stop cycles.

Following initialization, OneTouch™ will display the normal operation screen and indicate that the engine is ready to start. Pressing the green START button commences the autostart sequence. Engine rotation begins through the introduction of starting air. Rotational speed is displayed as a percentage of the maximum engine RPM limit as indicated by the N1% value. As N1 increases, fuel is introduced at the appropriate time and ignited thereby starting the combustion process. The displayed Turbine Inlet Temperature (TIT) value will show an immediate temperature rise indicating positive combustion. As N1 continues to increase, the Engine Pressure Ratio (EPR) relating combustion pressure to ambient pressure will also increase. Starting air remains on until the engine achieves a stable idle rpm and the TIT has cooled to an acceptable level.

The engine is now running and may be operated as desired. For reference purposes, an elapsed run-time counter displays the time since engine start. Stopping the engine is as easy as pressing the red STOP button. OneTouch™ continues monitoring the engine throughout the entire shutdown. Once N1 and TIT values are within safe start limits, OneTouch™ enables the engine for an immediate restart. Through OneTouch™, the engine may be repeatedly started and stopped without any adverse affect to the engine or the lab system.

During start and operation, should any critical engine value be exceeded or a problem found with any MiniLab™ or TurboGen™ system, OneTouch™ will command an engine shutdown and alert the operator to the problem. Faults are segregated between CAUTION and WARNING depending upon the severity of the problem and the operator intervention required to rectify the fault. A CAUTION is indicative of a minor problem that can be immediately fixed. Low fuel or oil levels are examples of CAUTIONs that are fixed simply by adding the appropriate fluid. A WARNING suggests the potential for a more serious problem that must be investigated before the engine can be run again. In the unlikely event a WARNING indication is experienced, the Operator's Manual provides detailed instructions to assist with the WARNING condition prior to any subsequent operation.

A software based system, OneTouch™ is easily upgraded and revised as changing requirements warrant. Hardware ports are available to facilitate interaction with the OneTouch™ system.

HushKit™ — Gas Turbine Sound Suppressor System

A gas turbine ducting system for the significant reduction of inlet and exit sound levels.

MiniLab™

TurboGen™

Product Summary

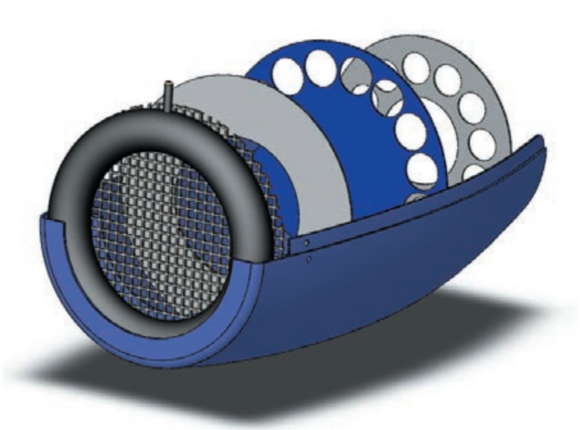
- Complete SR-30™ Gas Turbine Sound Suppressor System
- Typically Provides 84%~16dB(A) Intake and 75%~12dB(A) Exhaust Sound Reduction
- Aircraft Style, Nacelle Shaped Fiberglass Intake Suppressor Housing
- Stainless Steel Exhaust Suppressor Housing With Flame Plume Sight Window
- Installation Does Not Interfere with Engine Operation or Sensor Measurement
- Quick Installation Requires No MiniLab™ System Modifications
- Compatible with All Typical User Installations
- Requires No Operator Manipulation
- Supplied with Comprehensive Installation and Usage Instructions
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

The HushKit™ Gas Turbine Sound Suppressor System is an optional silencer assembly available for installation in the MiniLab™ Gas Turbine Power System. Designed to reduce the sound level of the SR-30™ Gas Turbine Engine, the HushKit™ is effective in both the academic and research setting and capable of retrofit to existing installations.

The HushKit™ system is composed of individual intake and exhaust suppressor units. The aircraft style, nacelle shaped intake suppressor housing is designed to reduce acoustic energy associated with compressor intake flow. Molded from aerospace quality fiberglass, the intake suppressor mounts to the SR-30™ Engine with a pneumatic friction seal system. This seal permits rapid installation and removal of the suppressor allowing full access to the engine inlet and compressor face for teaching and instructional purposes. The exhaust suppressor assembly is manufactured from stainless steel to maximize heat dissipation and durability. A positive pressure clamping system requires no modification of the existing MiniLab™ for installation. The suppressor exhaust ducting incorporates a glass sight window for flame plume visibility during starting operation. An acoustic expansion chamber on the end of the duct provides a convenient transition to facility specific exhaust ducting and integrates well with already existing installations. Neither the intake or exhaust suppressor assemblies interfere with engine operation.

Comprehensive installation and usage instructions are provided. Once installed, no additional operator manipulation is required. A free, two-year warranty is provided.



Details

Dimensions

Intake Suppressor:	10 inches ø x 32 inches (25 x 81 cm)
Exhaust Ducting:	6 inches ø x 36 inches (15 x 91 cm)
Exhaust Expansion Chamber:	10 inches ø x 10 inches (25 x 25 cm)

Expansion Chamber is integral to, and mounts over Exhaust Ducting

Weight

Intake Suppressor:	6 lbs (3 kg)
Exhaust Suppressor:	15 lbs (7 kg)

Operating Performance

Decibel (dB) Levels Without and With Suppressor System Installed in MiniLab

	Engine Speed 50,000 RPM			Engine Speed 84,000 RPM		
Position	3 feet	10 feet	25 feet	3 feet	10 feet	25 feet
Controller Side	97/90	94/88	91/79	107/98	102/94	99/90
Intake Side	120/103	112/91	103/86	124/113	121/106	108/96
Exhaust Side	113/93	100/88	92/80	116/104	107/100	103/92

Operating Conditions

Typical Laboratory Setting

Experimental Opportunities

The HushKit™ is primarily offered as an operational accessory to the MiniLab™ Gas Turbine Power System. With a growing sensitivity to noise and a greater emphasis placed on environmentally friendly engineering, the MiniLab™ / HushKit™ combination provides a platform for the further study of gas turbine noise.

- Gas turbine noise sources.
- Isolation and measurement of engine core and jet exhaust noise.
- Turbulence induced ambient air mixing in jet exhaust plume.
- Acoustic energy absorption and dissipation techniques.
- Engine performance degradation with various noise suppression methods.

Purchase Specifications

- A complete sound suppression system designed to reduce both engine core and jet noise.
- Inlet suppressor manufactured from molded fiberglass.
- Exhaust suppressor manufactured from stainless steel.
- Exhaust suppressor duct to be equipped with flame plume viewing window.
- Inlet and exhaust assemblies to be readily removable to allow access to engine.
- Inlet and exhaust assemblies to be mounted in such a way as to not interfere with any operation of the engine.
- To require no modifications of existing MiniLab™ unit.
- Provided with a comprehensive installation and usage instructions.
- To be covered by a free two-year warranty.

SprayView™ Fuel Atomization Verification System

A complete jet engine fuel manifold spray system used to demonstrate & verify proper atomization of various fossil and renewable heavy fuels.

Product Summary

- Portable Laboratory-Grade Fuel Atomization Verification System
- Clear-View Spray Observation Chamber with Spray Verification Impingement Plates
- Supplied with a Jet Engine Spray Manifold with Precision Variable Flow Control
- Instrumented with Fuel Delivery Pressure and Digital Fuel Flow Meters
- Requires No Tools, Facilities Modifications or Special Support to Operate
- Integrated Fuel Spray Vacuum Capture / Drain System
- Suitable for University, Technical and Military Education, Training and Research
- Supplied with Comprehensive Instructions
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

SprayView™ is an optional fuel spray testing system for the SR-30™ Gas Turbine Engine manufactured by Turbine Technologies, Ltd. It has been designed with a built-in engine spray manifold to allow MiniLab™ operators the ability to test the atomization characteristics of fuels before they are actually burned in the engine. Proper atomization verification is especially important for testing of alternative fuel formulations such as bio-diesels. Improper spray patterns signify fuel formulations that are not compatible with the existing engine fuel injection system. Attempting to run an engine with these non-conforming fuel formulations could potentially damage it.

The SprayView™ system also allows MiniLab™ operators to remove their actual SR-30™ Engine Fuel Spray Manifold and test it for proper operation. Injector nozzles can be inspected for any build-up of contaminants and can be conveniently cleaned for continued reliable performance when reinstalled on the engine. Periodic checks in this manner, especially when testing experimental fuel formulations, can reduce the chances of injector clogging, essentially eliminating potential engine operating problems.

SprayView™ features a clear view spray observation chamber allowing the operator to visually inspect the fuel spray pattern. Integrated impingement plates can be lined up under each spray nozzle to verify their spray integrity. The built-in fuel capture system pulls the injected fuel into a collection tank, which can be conveniently drained after the tests. An integrated spray throttling system allows the operator to vary the fuel spray to determine the optimum spray atomization "cloud" for a particular fuel. For students and researchers alike, the ability to actually see the fuel spray patterns, combined with concurrent readouts of system pressure and flow information provide a unique ability to verify fuel atomization integrity.

SprayView™ is self-contained and requires only 110V power for operation (220 Volt upon request). The system arrives fully assembled, tested and ready to use. Comprehensive utilization instructions are provided as well as a free, two-year warranty.

Details

Dimensions	SprayView™:	29" x 22" x 63"H (74 x 56 x 160 cm)
	As Shipped:	35" x 28" x 69"H (89 x 71 x 175 cm)
Weight	SprayView™:	160 lbs (73kg)
	As Shipped:	220 lbs (100kg)
Operators Panel	Digital Fuel Flow Meter Analog Fuel Pressure Gauge Keyed Master Switch Test Chamber Vacuum Switch Fuel Pump Switch	
Electrical	120 Volt (220 Volt upon request) 50 / 60 Hz 8 Amp	

Experimental Opportunities

SprayView™ is primarily offered as an accessory to the MiniLab™ Gas Turbine Power System. With the growing need to do more with existing equipment, the MiniLab™ Gas Turbine Power System finds itself being used by undergraduate students working to gain an understanding of the Brayton Power Cycle as well as researchers testing alternative fuel formulations for performance and emissions results. The ability to verify fuel integrity and to check an existing SR-30™ engine fuel manifold for potential fuel injector clogging contaminants are major considerations for using the SprayView™.

- Check spray pattern and Integrity of various heavy fuel formulations.
- Verify proper operational integrity of in-service engine spray manifold.
- Suitable for integrating various atomization sensors such as lasers for advanced research.

Purchase Specifications

- An atomization system for testing heavy fuels.
- A see through spray observation chamber.
- Unit to include integrated spray verification impingement plates.
- Built-in fuel throttle.
- Vacuum fuel collection system.
- Stainless steel fuel tank.
- Stainless steel cabinetry.
- Included engine spray test manifold.
- An electric fuel pump.
- A mechanical fuel pressure gauge.
- A digital fuel flow meter.
- Keyed master power switch.
- Built-in locking casters for easy portability.
- Fully assembled and ready to operate.
- Provided with a comprehensive Operator's Manual.
- To be covered by a free two year warranty.

SR-30™ Cutaway

Turbojet Engine

A full-scale turbojet engine manufactured to reveal the inner workings and engineering details of a gas turbine power plant.

Product Summary

- Complete SR-30™ Turbojet Engine Cutaway
- Compressor and Turbine Stages Readily Viewable
- Ball Bearing Mounted Rotating Assembly Permitting Full Rotation
- Turbomachinery Components Reveal Actual Blade Geometries
- Reverse Flow Annular Combustor Can Clearly Visible
- Provided with Black Anodized Aluminum Mounting Stand
- Complete with Custom Storage and Transportation Case
- Supplied with a Comprehensive Teaching Narrative
- Designed to Meet ABET Criterion 4 and 6 Objectives
- Industry Leading Warranty with Unsurpassed End-User Support
- Designed and Manufactured in the USA

Description

The SR-30™ Gas Turbine Engine is designed and manufactured by Turbine Technologies, LTD specifically for the MiniLab™ Gas Turbine Power System. The SR-30™ Cutaway is a full scale example of the actual operating power plant with portions of selected components removed to reveal the inner workings of the engine.

A pure turbojet, the SR-30™ is representative of all straight jet engines in which combustion results in an expanding gas that is sufficiently capable of producing useful work and propulsive thrust. Consisting of a centrifugal compressor, annular combustor and axial flow turbine, the SR-30™ engine is typical of the gas generator core found in turbofan, turboprop and turboshaft gas turbine engines used for aero and marine propulsion and industrial applications.

Flow path analysis is the preferred method to introduce gas turbine operating principles. With the SR-30™ Cutaway, the entire flow process from inlet to exit is traceable, matching the path the actual fluids take through an operating engine. Each major component can be investigated in turn with study given to how the individual parts contribute to the overall function of the engine. Showcasing the complex internal configuration of the basic turbojet, the SR-30™ Cutaway facilitates the qualitative understanding of gas turbine fundamentals and establishes a foundation for more advanced study. The SR-30™ Cutaway completes the MiniLab™ Gas Turbine Power System. It is equally effective as an independent teaching aid and will further the understanding of gas turbine engine operation in any context.

Unlike other cutaways or display models, the SR-30™ Cutaway is meant to be handled and used for demonstration purposes. Hands on manipulation of the rotating assembly and the ability to conduct tactile exploration of the flow path enhance the potential for learning. Supplied with a rugged, road style transportation case, the SR-30™ Cutaway may be safely transported and securely stored. A free, two year warranty is provided on the SR-30™ Cutaway engine.

A comprehensive teaching narrative is provided. It utilizes the SR-30™ Cutaway to illustrate gas turbine concepts and operation. Additional material relating to the manufacturing and assembly process is also included.

Details

Dimensions

SR-30™ Cutaway:	14.5 x 11.0 x 8.0 inches (37 x 28 x 20 cm)
Storage Case:	18.0 x 14.0 x 12.0 inches (46 x 36 x 31 cm)

Weight

SR-30™ Cutaway:	10 lbs (5 kg)
Storage Case:	23 lbs (10 kg)
Combined:	33 lbs (15 kg)

All Actual and Representative Components

- Inlet Bell and Compressor Casing
- Compressor Spinner / 2 Pole Generator for Engine RPM Sensing
- Centrifugal Flow Compressor and Diffuser
- Reverse Flow Annular Combustor with Laser Cut Air Flow Holes
- Outer Combustor Mantle
- Metal Spun Combustor Transition Liner
- Nozzle / Vane Guide Ring
- Bladed Axial Flow Turbine Disk with Main Engine Shaft
- Turbine Containment Ring
- Thrust Cone and Thrust Nozzle
- Fuel Manifold, Fuel Nozzles, Fuel Control Unit and Engine Backplate
- Compressor and Turbine Oil Seals and Main Bearings
- Typical Air, Fuel and Oil Fittings with Internal Engine Fluid Galleyways

Storage Case

Air Transport Association Approved Delicate Equipment Case
Fully Lined and Latchable for Safe, Secure Transportation

Experimental Opportunities

- Gas turbine fundamentals.
- Mechanical operating principles.
- Detailed flow path analysis and visualization.
- Mass and volume flow calculations.
- Construction of blade angle, flow and vector velocity diagrams.
- Examination of typical jet engine manufacturing and construction techniques.

Purchase Specifications

- A complete, full-scale turbojet engine with portions of selected components removed to reveal the inner workings of the engine.
- Engine to utilize a centrifugal flow compressor, reverse annular flow combustor and an axial flow turbine stage.
- Engine to be of current manufacture and consisting of all new components.
- Engine sufficiently open and accessible to trace entire gas flow through all components.
- Rotating assembly capable of full rotation as in operating engine.
- Engine supplied with and displayable on black anodized aluminum mounting stand.
- To be supplied with a latchable aluminum ATA approved travel and storage case.
- Provided with a comprehensive teaching narrative.
- To be covered by a free two year warranty.

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