PRESSURE SYSTEMS
A Roxboro Group Company

8400 Flow Reference System

ISO-9001 Certified

8401

FEATURES

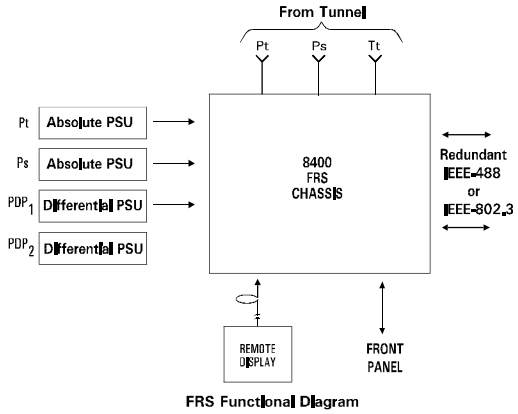
- Autoranging Pressure Measurement with Built-In Over-Pressure Protection
- ±0.01% Uncertainty 0-15 to 0-500 psia
- ±0.02% Uncertainty 0-5 to 0-100 psid
- IEEE-488 or Ethernet Interfaces
- On-Line Rezero
- Optional High Accuracy Temperature Measurements

APPLICATIONS

- Windtunnel Mach Number Measurement

The 8400 Flow Reference System (FRS) is a self-contained multirange pressure measurement system for windtunnel static and total pressure measurement. An optional total temperature measurement system for a user-supplied platinum RTD can also be included. These measurements are crucial to the determination of critical windtunnel parameters such as Mach number, dynamic pressure, wind speed, and Reynolds number. The inherent accuracy of the FRS provides the ability to derive Mach number to an accuracy of ±0.001 for most facilities.

Based on the System 8400 product family, the FRS consists of a rackmountable micro-processor-based chassis called a System Processor (SP). The SP houses up to four modular Pressure Standard Units (PSU) each incorporating a high accuracy pressure standard. The PSUs also incorporate internal valving under microprocessor control to provide autoranging, overload protection and rezero of the differential pressure standards. The SP supports IEEE-488 or Ethernet IEEE 802.3 interfaces. The instrument provides dual IEEE-488 interfaces to permit two computers to simultaneously acquire data from the FRS.



FRS Functional Diagram

The compact design of the FRS enables the system to be mounted near the test section at the centerline of the windtunnel to minimize pressure lag and hydrostatic effects. Optionally, the system can be configured to remotely locate the pressure standards near the static and total probes to further reduce pressure lag.

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KPSI

8401 Specifications

Parameter	8401	Units	Comments
PNEUMATICS			
Pressure Ranges **Absolute**	15 / 105 23 / 160 30 / 210 45 / 300 65 / 450 100 / 690 200 / 1380 300 / 2070 500 / 3500	psia / kPa	Model 8438 Maximum of 4 PSU
Differential	0.5 / 3.5 1.0 / 7 2 / 14 5 / 35 10 / 69 15 / 105 30 / 210 50 / 350 100 / 690	psid / kPa	Model 8439 Maximum of 4 PSU
Media	Dry, non-corrosive gases		
Overpressure **Absolute (8438)** **Differential (8439)[1]**	 1.2 1.3	 x F.S. x F.S.	
Max Line Pressure **Line Pressure Effects**	100 / 690 ±0.002	psia / kPa %FS / psia	 ≤ 2 psid
Temperature Measurement Range	75 to 325	Kelvin	optional
STATIC PERFORMANCE			
Measurement Resolution **Absolute (8438)** **Differential (8439)** **Temperature**	 ±0.001 ±0.003 ±0.0005	 % F.S. % F.S. K	 Model 8438 Model 8439 temp. measurement opt.
Relative Accuracy[2] **Absolute (8438)** **Differential (8439)**	 ±0.01 ±0.02 ±0.025	 % F.S. % F.S. % F.S.	 ≥ 5 psid < 5 psid
Thermal Stability	±0.002	% F.S./ºC	
Longterm Stability **Absolute (8438)** **Differential (8439)[3]**	 ±0.01 ±0.03 ±0.02	 % F.S./6 mo % F.S./6 mo % F.S./6 mo	 <2 psid ≥2 psid
Temperature Accuracy[4]	±0.03	K/6 mo	
Measurement Rate **Triggered** **Free Run**	 10 5	 readings/sec readings/sec	 Maximum Fixed
Pressure Settling Time for 5 psid step	0.25	sec/5 psid step	

Specifications subject to change without notice.

Specifications 8401

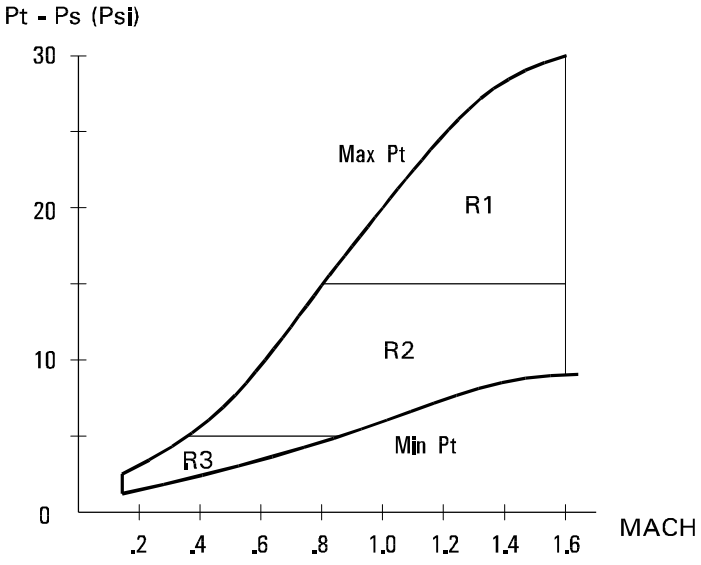
Parameter	8401	Units	Comments
DIGITAL INTERFACE			
IEEE-488	Dual interface		
Ethernet IEEE 802.3	Single interface		optional
POWER REQUIREMENTS			
Input Voltage	100 - 240	VAC	
Input Power	200	W	
ENVIRONMENTAL/PHYSICAL			
Calibrated Temperature Range	0 to 40	ºC	
Operating Temperature Range	-20 to 50	ºC	
Storage Temperature	-20 to 70	ºC	
Weight	80 36	lb kg	

Notes:

1 FRS provides programmable pneumatic overload protection for differential transducers.
2 Includes effects of linearity, hysteresis, line pressure effects, and thermal stability. Specification for differential units is immediately following on-line pneumatic rezero.
3 After on-line pneumatic rezero.
4 Does not include errors of platinum RTD temperature sensor (user supplied).

Specifications subject to change without notice.

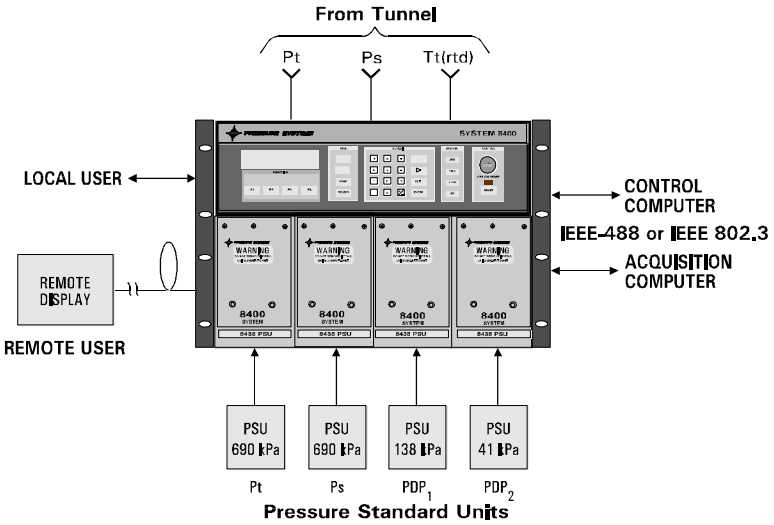
Modern wind tunnels require the measurement of the physical properties of wind flow with a high degree of accuracy. The aerodynamic parameters of interest cannot be measured directly. These include Mach Number (Ma), Dynamic Pressure (Q), Flow Velocity (V), and Reynolds Number (Re). The quantities that can actually be measured are Total Pressure (Pt), Static Pressure (Ps), Pressure Difference (Pt - Ps), and Total Temperature (Tt). For many transonic wind tunnels, the large dynamic range of tunnel operation makes these measurements very challenging. It is not uncommon in transonic wind tunnels for the pressure difference of Pt - Ps to range from .3 PSI (2 kPa) to more than 30 PSI (210 kPa) while, over that complete range, a relative accuracy on the order ±0.1% is required. To achieve the required accuracies over these large dynamic ranges, the use of multiple precision pressure transducers is required. Before development of the Flow Reference System (FRS), most wind tunnel facilities developed in-house flow measurement systems based on custom hardware and software. These systems typically rely on laboratory-type precision pressure transducers which must be located away from the tunnel to maintain proper environmental conditions. The 8401 FRS provides a pre-engineered solution to wind tunnel flow parameter measurement, by incorporating rugged pressure transducers. The integral ability to select the optimal range transducer for a given tunnel operating condition maximizes measurement accuracy throughout the wind tunnel's operational envelope.

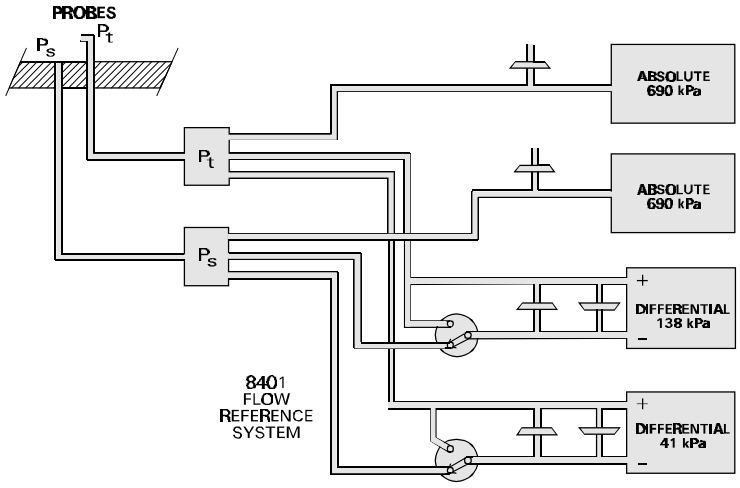


Wind Tunnel Operating Envelope

The 8401 is based on PSI's proven 8400 pressure scanning system. The instrument consists of the 8400 SP chassis with up to 4 Pressure Standard Units (PSUs). Pneumatic inputs for tunnel total pressure (Pt) and tunnel static pressure (Ps) connect to the rear of the chassis. These pressures are internally manifolded from the rear panel to each PSU in the chassis. Optionally, total temperature (Tt) can be measured by connecting a user-supplied platinum RTD to the rear of the chassis through a circular bayonet-type connector. The FRS interfaces to facility computers via the IEEE-488 interface or the Ethernet IEEE 802.3 serial interface. Dual IEEE-488 interfaces enable data to be simultaneously output to separate computers for facility control and model data acquisition.

Operator interface is provided through the front panel or an optional remote display unit. The instrument is packaged in a 19" rackmountable chassis and is rugged enough to permit placement near the tunnel, typically at the centerline, to eliminate the hydrostatic pressure effects and to minimize pneumatic pressure lags.





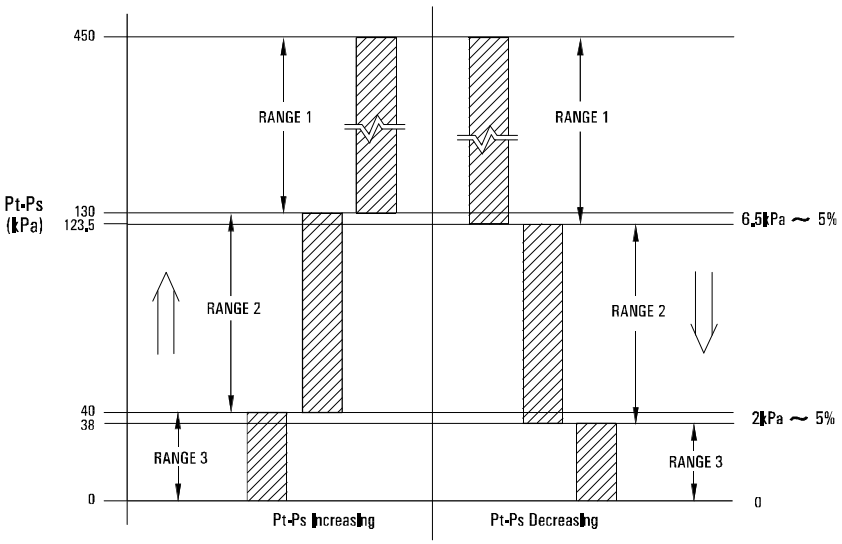
Accurate measurement of individual pressures is made by 8400 Pressure Standard Units (PSUs). The PSU consists of a high accuracy (±0.01%) pressure transducer, such as a vibrating quartz beam transducer, for absolute pressure measurement or a proprietary High Accuracy Silicon Standard (HASS) transducer for measurement of differential pressures. The PSU contains the necessary data acquisition circuitry (frequency counter or A/D converter) along with a microprocessor for control and interface to the VME processor.

Overpressure protection for the PSU is provided by a pneumatic relief valve set at approximately 1.20 times full scale pressure. The differential PSUs are further protected by a solenoid valve which, when deactivated, protects the pressure transducer and simultaneously allows the system to pneumatically rezero the differential HASS transducers. The solenoid's setpoint is selected by the user during setup and stored in the system's nonvolatile memory.

Transducer calibration coefficients are stored in nonvolatile memory within the PSU. This feature allows the PSU to be moved from system to system without having to transfer coefficients.

PRESSURE TRANSDUCER AUTORANGING

During operation, the system automatically selects the most sensitive differential PSU, based on the tunnel operating conditions. As the difference between Pt and Ps exceeds the full scale range of the PSU, this PSU is automatically switched out by closing the pneumatic solenoid valve, which shunts together both sides of the differential pressure transducer. During initialization, the user may select the pressure levels for switching in and switching out of the various PSUs. At maximum tunnel operating conditions, the difference between Pt and Ps is typically calculated by subtracting the total pressure and static pressure, as measured by 2 absolute PSUs. The autoranging function has built-in hysteresis, allowing the FRS to switch to a higher range at one pressure, while
using a lower pressure value to switch back to the lower range.



FRS OPERATION

Upon power up, the FRS executes an auto initialization and then begins acquiring data at 5 readings per second. Users can acquire data asynchronously or can take data synchronously by triggering the FRS before each measurement. System operation is controlled by simple commands sent over the interface. The FRS recognizes the following commands:

Command	Description
PC	Trigger measurement
PP	Request Data
PZ	Re-zero
PY	Reset
PX	Exit (to 8400 mode)

The "PC" command causes the FRS to acquire one set of measurements. The instrument may be triggered at up to 10 measurement sets per second.

The "PP" command causes the FRS to transmit the acquired data record to the host computer. Data is returned to the host computer in the following order:

Status
Pt
Ps
Pt - Ps1
Pt - Ps2
Tt
CRS-16

The "PZ" command corrects the differential pressure measurements for zero shift due to time, temperature or line pressure. PSUs which do not contain a differential pressure transducer ignore this command.

The "PY" command or an IEEE-488 device clear command restarts the system as if a power up or front panel reset occurred. After this command, the FRS requires several seconds to automatically configure and begin operation.

The "PX" command restarts the system in the standard 8400 mode. This mode is useful to perform system configuration, calibration, or maintenance.

A 16-bit status word (PSW) is included in each data record to monitor system integrity. The PSW indicates which range has been selected, provides status of transducer accuracies for Pt - Ps when multiple ranges are activated, provides the system identification number, provides information about transducers which may be out of range, and finally, provides information regarding command/system errors. The system status bits are summarized in the following table.

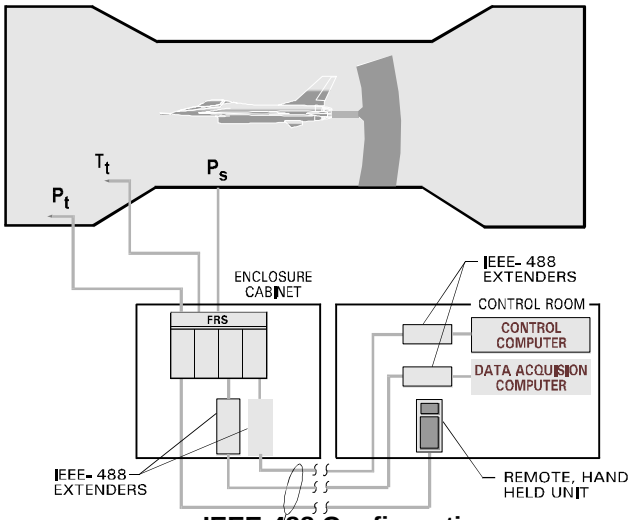
Bit	Function
0	Differential pressure range 1
1	Differential pressure range 2
2	Differential pressure range 3
3	(Pt - Ps)/(Pt - Ps)1 discrepancy
4	(Pt - Ps)1/(Pt - Ps)2 discrepancy
5	(Pt - Ps) out of range
6	(Pt - Ps)1 zero error
7	(Pt - Ps)2 zero error
8	System ID Bit 0
9	System ID Bit 1
10	Re-zero busy
11	Transducer's pressure out of range
12	Transducer's temperature out of temperature range
13	Total temperature measurement out of range
14	Command error
15	System error

The status bits allow the host computer to quickly monitor system health and PSU error conditions. Typically, this data is recorded with the measurements as a data validity record.

The FRS recognizes a number of other commands which are used to initialize the system, to read out and store transducer coefficients, to select engineering output units, and to set values such as pressure switching thresholds, etc.

Installation

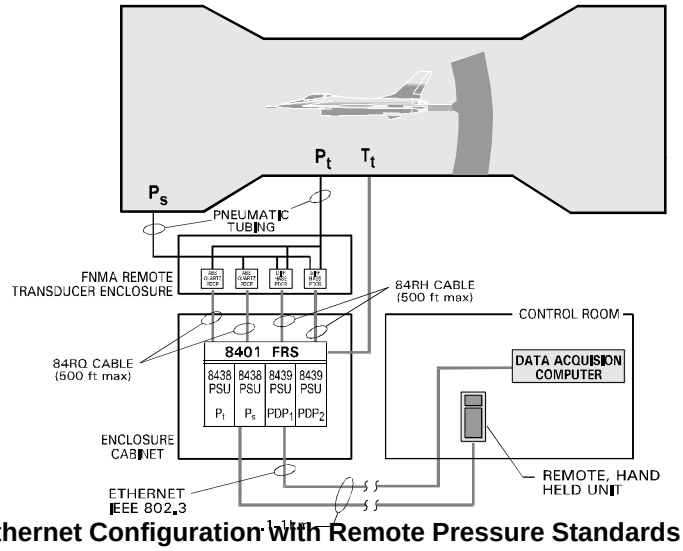
The FRS is typically installed near the windtunnel, midway between the Pt and Ps probes, so that pneumatic response times are approximately equal. The FRS should be mounted near the centerline of the tunnel so that hydrostatic effects in the Pt and Ps pneumatic tubing do not affect accuracy. Optionally, the system can be configured to remotely locate the pressure standards near the static and total probes to further reduce pressure lag.



IEEE-488 Configuration

IEEE-488

Dual IEEE-488 interfaces are standard. Both interfaces can acquire data independently of the other. This feature allows the FRS to be used for both data acquisition and control functions. Due to the length limitations of the IEEE-488, interface extenders are required if the FRS is located more than 20m from the host computer(s).



Ethernet Configuration with Remote Pressure Standards

Ethernet

An optional Ethernet interface is available for applications in which the FRS and host computer are separated by a long distance.

8401 Ordering Information

PN: 8401-AABBCC0000 **Flow Reference System Processor**

AA = Power Supply
- 01, 120 VAC
- 02, 240 VAC

BB = Total Temperature Measurement
- 01, No Option
- 02, Total Temperature Option

CC = Interface
- 01, IEEE-488 (standard)
- 02, IEEE 802.3 (optional)

PN:8438-AA00010000 **Absolute FRS Pressure Standard Unit**

AA = Pressure Range (Consult Factory for ranges not listed)

01, 15 psia (105 kPa)	05, 65 psia (450 kPa)
02, 23 psia (160 kPa)	06, 100 psia (690 kPa)
03, 30 psia (210 kPa)	07, 300 psia (2070 kPa)
04, 45 psia (300 kPa)	08, 500 psia (3500 kPa)

PN: 8439-AA00010100 **Differential FRS Pressure Standard Unit**

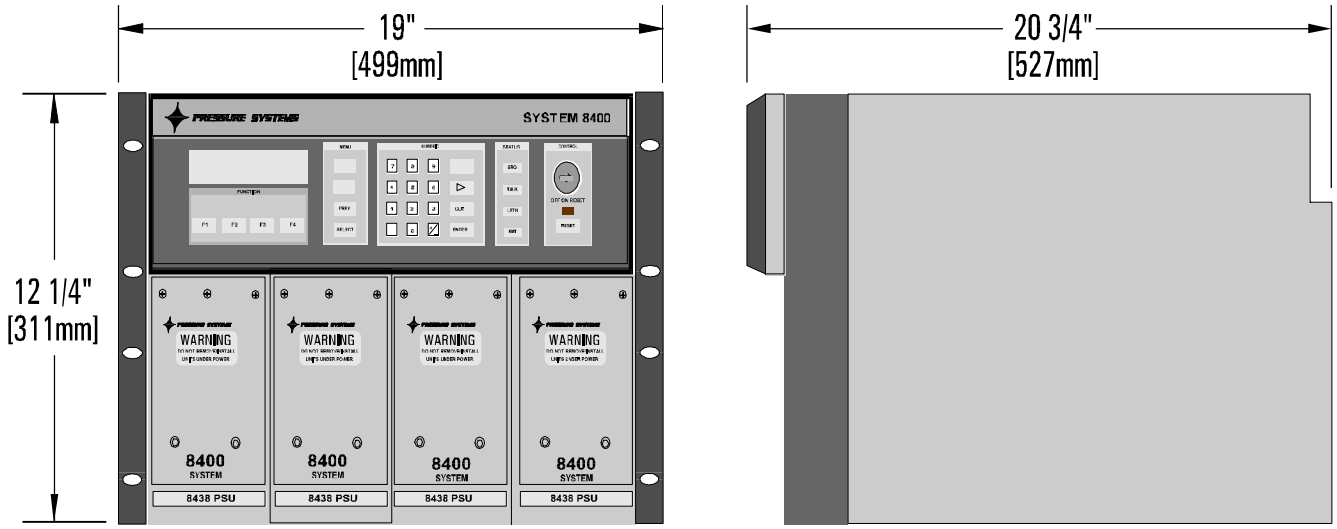
AA = Pressure Range (Consult Factory for ranges not listed)

02, 5 psid (35 kPa)	09, 50 psid (350 kPa)
04, 2 psid (14 kPa)	10, 10 psid (69 kPa)
06, 15 psid (105 kPa)	12, 100 psid (690 kPa)
08, 30 psid (210 kPa)	13, 20 psid (140 kPa)

PN: RTHU **Remote Transducer Housing Unit**

PN: RTCB-AAA **Remote Transducer Cable**

AAA = Length in feet (ie .001, 1 foot
010, 10 feet
100, 100 feet)



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