SuperFlow
DYNAMOMETERS & FLOWBENCHES
A Division of Power Test, Inc.

Operator Manual

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AUTODYN

Original Instructions

www.PowerTestDyno.com

Computerized Engine and Vehicle Test Systems

SuperFlow®
DYNAMOMETERS & FLOWBENCHES
A Division of Power Test, Inc.

Trademark Notices

Please keep this manual for future reference.

This manual is intended to assist operating personnel in becoming familiar with the product and as guidance in ordering necessary parts inclusive of Axiline's warranty requirements. Maximum operating efficiency and life of any Axiline Precision Product will be attained through complete understanding of the instructions and recommendations contained within this manual.

⚠ WARNING
Services performed beyond preventive maintenance by personnel other than Axiline Service Technicians on any Axiline products during the warranty period may void the warranty.

IMPORTANT
When available, please include the model number and serial number of the product in any correspondence.

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General Information

1.1 Safety Warnings

WARNING: To ensure safe operation, this equipment must only be operated according to the instructions in the *SuperFlow AutoDyn Operator's Manual*. It is also essential that this equipment is installed, maintained, and operated according to local safety requirements.

Any person instructed to carry out installation, maintenance or repair of the equipment must read and understand the *AutoDyn Operator Manual* and in particular the technical safety instructions. Any users of this equipment must operate only the controls of the equipment. Only qualified personnel should remove exterior panels and service equipment.

1.1.1 Dangers Due to Non-observance of Safety Instructions

- Carbon monoxide poisoning
- Hearing damage due to high noise levels
- Electrical shock
- Exposure to rotating parts

1.2 General Safety Procedures

CAUTION: Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around Printed Circuit Boards (PCBs).
- Do not touch the components or conductors on a PCB with your hands or with conductive devices.

CAUTION: To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Always follow basic safety precautions when using this product to reduce risk of injury and/or damage to equipment.

- Only authorized personnel trained in the operation of the dynamometer should have access to the equipment.
- Read and understand all instructions in the user guides.
- Use only the proper electrical sources as prescribed in the installation guide. Ensure circuit breakers are easily accessible and have the proper rating.
- Observe all warnings and instructions marked on the product.
- Ensure proper ventilation of exhaust gases from the vicinity of the dynamometer

- Provide fire extinguishers that are rated for electrical and oils.
- Provide adequate lighting in the test cell and at the operators console.
- Always wear proper protective clothing and eye/ear protection.
- Refer all service questions to qualified personnel.
- Do not remove any safety guards while the machine is in operation and be sure the safety guards are correctly mounted before operating the device.
- Disconnect the external power switch before opening the rear panel of the device.
- Replace the power cable if it is damaged.
- Keep the air inlet grids free of dust or dirt.
- Keep loose material away from the inlet and exhaust air ducts.
- Do not store flammable materials in the vicinity of the dynamometer.
- Keep all personnel, flammable items, and sensitive objects away from any rotating object that can throw debris radially outward.

1.3 Room Requirements

When working in or building a test cell:

- Follow all local construction codes.
- Install a Carbon Monoxide (CO) detector in the test cell.
- Provide fire extinguishers that are rated for gasoline and oils.
- Provide adequate lighting in the test cell and at the operators console.
- Provide a means outside the test cell to turn off the ventilation fans and electrical circuits.

1.4 Noise Levels

SuperFlow Technologies Group always recommends ear protection when operating any product.

Warning Signs of Hazardous Noise[1]

- You must raise your voice to be heard.
- You cannot hear someone two feet away from you.
- Speech around you sounds muffled or dull after leaving a noise area.
- You have pain or ringing on your ears (tinnitus) after exposure to noise.

1. Information in this section was adapted from “Noise and Hearing Loss,” American Speech-Language-Hearing Association, 1997–2007, **http://www.asha.org/public/hearing/disorders/noise.htm**, 2007.

Hazardous Noise

Both the amount of noise and the duration of exposure determine the amount of damage to hearing. Noise levels are measured in decibels (dB). The higher the decibel level, the louder the noise. Hair cells of the inner ear and the hearing nerve can be damaged by an intense brief impulse (such as an explosion) or by continuous or repeated exposure to noise.

For sound levels of 85 decibels (dB) or above, use hearing protection. Please follow all safety standards when operating this or any equipment.

1.5 Carbon Monoxide Warnings

When operating fuel-generated equipment in enclosed areas, take the following precautions to protect you and your employees against carbon monoxide exposure.

What is carbon monoxide?[1]

Carbon monoxide (CO) is a poisonous, colorless, odorless, and tasteless gas. Although it has no detectable odor, CO is often mixed with other gases that do have an odor; therefore, you can inhale carbon monoxide right along with gases you can smell and not even know that CO is present.

CO is a common industrial hazard resulting from the incomplete burning of natural gas and any other material containing carbon such as gasoline, kerosene, oil, propane, coal, or wood. One of the most common sources of exposure in the workplace is the internal combustion engine.

How does CO harm you?

Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen. Large amounts of CO can overtake you in minutes without warning—causing you to lose consciousness and suffocate.

Besides tightness across the chest, initial symptoms of CO poisoning may include headache, fatigue, dizziness, drowsiness, or nausea. Sudden chest pain may occur in people with angina. During prolonged or high exposures, symptoms may worsen and include vomiting, confusion, and collapse in addition to loss of consciousness and muscle weakness. Symptoms vary widely from person to person. CO poisoning may occur sooner in those most susceptible: young children, elderly people, people with lung or heart disease, people at high altitudes, or those who already have elevated CO blood levels such as smokers. CO poisoning poses a special risk to fetuses.

Acute poisoning may result in permanent damage to the parts of your body.

1. Information in this section was adapted from the “OSHA Fact Sheet,” U.S. Department of Labor, Occupational Safety and Health Administration, 2002, **http://www.osha.gov/OshDoc/data_General_Facts/carbonmonoxide-factsheet.pdf**, 2007.

How can employers help prevent CO poisoning?

To reduce the chances of CO poisoning in your workplace:

- Install an effective ventilation system that will remove CO from work areas.
- Maintain equipment and appliances that can produce CO to ensure they are in good working order, promote their safe operation, and reduce CO formation.
- Consider switching from gasoline-powered equipment to equipment powered by electricity, batteries, or compressed air if it can be used safely.
- Prohibit the use of gasoline-powered engines or tools in poorly ventilated areas.
- Provide personal CO monitors with audible alarms if potential exposure to CO exists.
- Test air regularly in areas where CO may be present, including confined spaces.
- Install CO monitors with audible alarms.
- Use a full-face piece, pressure-demand, Self-Contained Breathing Apparatus (SCBA) certified by the National Institute for Occupational Safety and Health (NIOSH) or a combination full-face piece, pressure demand supplied-air respirator with auxiliary self-contained air supply in areas with high CO concentrations (those immediately dangerous to life and health atmospheres).
- Use respirators with appropriate canisters for short periods under certain circumstances where CO levels are not exceedingly high.
- Educate workers about the sources and conditions that may result in CO poisoning as well as the symptoms and control of CO exposure.
- In addition, if your employees are working in confined spaces where the presence of CO is suspected, you must ensure that workers test for oxygen sufficiency before entering.

What can employees do to help prevent CO poisoning?

To reduce the chances of CO poisoning in the workplace, employees should:

- Report any situation to your employer that might cause CO to accumulate.
- Be alert to ventilation problems—especially in enclosed areas where gases of burning fuels may be released.
- Report promptly complaints of dizziness, drowsiness, or nausea.
- Avoid overexertion if you suspect CO poisoning, and leave the contaminated area.
- Tell your doctor that you may have been exposed to CO if you get sick.
- Avoid the use of gas-powered engines, such as those in powered washers as well as heaters and forklifts, while working in enclosed spaces.

What are the OSHA standards for CO exposure?

The OSHA PEL is 50 parts per million (ppm). OSHA standards prohibit worker exposure to more than 50 parts of the gas per million parts of air averaged during an 8-hour time period.

For more information on carbon monoxide, visit the OSHA Web site at **http://www.osha.gov**.

2

System Overview

2. System Overview

AutoDyn with Corvette

2.1. Purpose

The AutoDyn vehicle dynamometer is a chassis dynamometer ("rolling road") designed to allow testing of passenger cars, sport utility vehicles, light trucks, and similar vehicles within the workshop environment.

Typical applications include:

- Performance testing
- Diagnostic testing
- Education
- Vehicle certification
- Research and development

Testing on a dynamometer reduces road testing liability, improves measurement accuracy, and enhances productivity.

The AutoDyn is a scalable system which can be customized to fit your requirements.

2.2. Components

The AutoDyn dynamometer consists of three major components. These are the frame assembly, the sensor box, and the absorber module (if applicable).

A more detailed description of each of these components follows.

2.3. Frame Assembly

The frame contains the rolls, roll shaft or axle, air-actuated roll brakes, and a tachometer gear with magnetic pick-up.

The frame is boxed for improved stiffness and to achieve the most compact design. The absorber is driven off the axle differential pinion gear via a drive-shaft. The axle is mounted in trunnion bearings and a load cell connects the differential to the frame. All parasitic losses are measured by the load cell, except the windage (aerodynamic losses) of the rolls. The windage is measured at the factory and compensated in the software. The rolls are mounted on the axle wheel flanges and can be removed after unbolting end plates on both sides of the frame.

The truck axle differential allows the use of different axle ratios for different applications. The standard ratios are 2.79:1 for Eddy Current absorbers. This selection is based on a maximum design speed of 200 mph. Other axle ratios result in different speed and power characteristics of the dynamometer.

The rolls have a nominal diameter of 42” (106.7 cm) and are 28” (71.1 cm) wide. They are spaced 28” (71.1 cm) apart. The inertia of the rolls is measured by SuperFlow to provide an exact calculation of power when the roll is accelerated. This inertia value is stored in the sensor box electronics.

A magnetic pick-up detects the teeth on the tachometer gear. This frequency is then converted to roll speed via the CPU printed circuit card and the system software. The magnetic pick-up also creates a signal that interlocks the roll brakes and lift or ramp commands (if applicable) while the roll is rotating.

The roll brakes consist of a hydraulic disk brake installed on the differential pinion shaft. The brakes are actuated by an air solenoid, which must be supplied with 100 psi (690 kPa) air pressure.

An electrical interface box is mounted on the dynamometer frame. On the dynamometer side, this interface box is wired to the load cell, the magnetic pick-up, the roll lock solenoid, and the absorber. The interface box groups all dynamometer data and control signals for connection to the sensor box. The sensor box is connected with a single cable.

For above-ground installations, the dynamometer frame can be equipped with restraint bars, which offer convenient tie-down points for one end of the vehicle. For pit installations, tie-down points should be embedded in the concrete floor slab.

Place the dynamometer frame assembly so that it is on a level surface. Reducing any twisting stress on the main frame will enhance overall durability and improve measurement accuracy. Jack feet are provided for easy alignment.

Differential oil cooler (optional)

On some models, a differential oil cooler may be supplied for endurance testing. This cooler consists of a thermostatically controlled oil-to-water heat exchanger, a circulation pump, and an oil filter. Thermocouple temperature measurements are provided and quick connect couplings are used.

2.4. Power Absorber Assemblies

The (optional) absorber packages are used to simulate additional inertia, or to measure power at a constant speed. The AutoDyn can be equipped with two different absorber packages. Both are mounted in a specific module, which attaches to the front of the dynamometer frame. The absorbers are connected to the truck axle differential (and thus the rolls) via a short drive-shaft. The addition of an absorber to the system allows speed or torque control. This feature allows the user to run constant speed, constant torque, or controlled acceleration tests.

The load cell measures the total force applied by the vehicle and sends an analog voltage to the CPU for conversion and measurement. Because the axle is trunnion-mounted, all torque reaction forces are measured by the load cell mounted on the differential and there is no need for trunnion-mounting the absorber. This improves the accuracy of torque measurement and makes it independent of differential oil temperature or absorber alignment. The force measured is only as accurate as the calibration that must be performed on the unit. If the calibration is off by five percent, then the measurement will be off by five percent as well. The axle has mounting points for a torque calibration arm. The calibration arm is supplied with the dynamometer.

Both types of absorber modules available for the AutoDyn are described below.

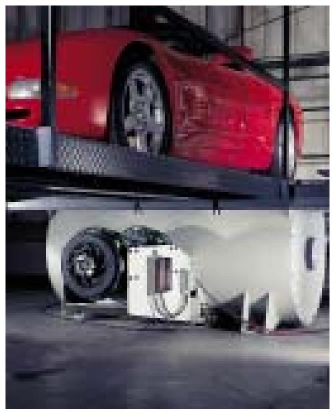
2.4.1. Single Eddy Current absorber module

A module with a single, air-cooled eddy current absorber is attached to the dynamometer. The load is applied by generating an electric field in which rotors of magnetic material turn. This results in an electro-magnetic resistance to rotation, which can be controlled by varying the current in the coils generating the electric field.

Eddy Current absorbers achieve fast response, excellent stability, and high torque at low speeds. An air-cooled eddy current absorber must dissipate all power into the air circulating through the rotors. For high power applications, the rotors will heat up rapidly which will reduce their power capability. For this reason, an air-cooled eddy current absorber is suitable for short high-power runs with sufficient cooling time between runs, or for low power testing over longer periods of time. The main advantage of the air-cooled eddy current absorber is the ease of installation: no external cooling systems are required.

2.4.2. Dual Eddy Current absorber module

A module containing two identical eddy current absorbers is attached to the dynamometer. This module operates in exactly the same way as the single eddy current absorber module, except it almost doubles the power absorption capacity of the dynamometer.



2.5. Sensor Box

Pro Sensor Box

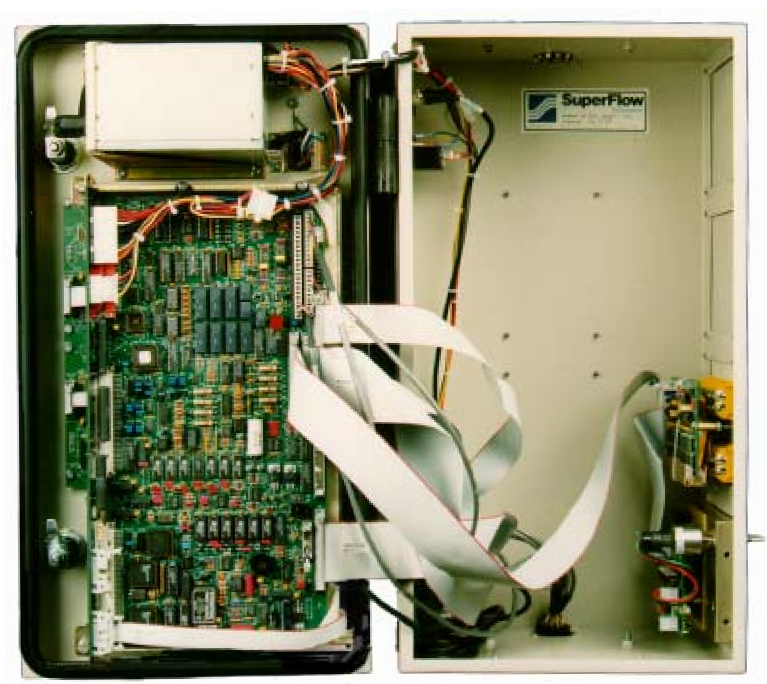
The sensor box contains the CPU (Central Processing Unit) printed circuit card, thermocouple printed circuit card, pres-sure printed circuit card, and the user interface printed circuit card. Data that is recorded and displayed by the dynamometer is measured by these printed circuit cards. The system measures the Engine Speed, and Roll Speed as frequencies, and then converts these frequencies to digital information. The Load Cell (with absorber models) measures the torque produced by the vehicle as an analog voltage, and converts that voltage to digital information. The pressures and thermocouples are also measured as analog voltages, and converted to digital information. A barometric pressure transducer is located inside of the sensor box. This transducer produces an analog voltage that is converted to digital information.There are also “Specifications” that are not measured, but actually entered by the user. Specifications configure the system for each vehicle. These are used for calculations of some of the data displayed by the system.

From 2 to 8 LCD displays are available, depending on the model configuration.

2.6. Specifications

The AutoDyn dynamometer uses SuperFlow's New Generation Electronics (NGE) for state-of-the-art data acquisition and control performance. Two levels of NGE are used:

Some older models use the SF-1942/2060 board-set



Technical specifications for each board-set are listed below.

NGE Data Acquisition and Control System Specifications

SF-2620 board based systems

Processor

- *Two MC 68332 microcontroller*
- *Clock speed 25 MHz*

On-board memory

- *1MB Operating System Flash ROM*
- *1 MB of battery backed SRAM.*

  1 MB non-batery-backed SRAM

Network communication

- *IEEE 802.3 MAC Network controller with 10-Base-2 and 10 Base-T Ethernet interface*
- *NetBEUI protocol*
- *16k Dual port RAM interface*

Data Acquisition

8-channel, 12 bit serial interfaced Analog to Digital Converter (ADC) expandable to hundreds of channels via on-board multiplexing

Data acquisition rate

- *Base rate: 1200 Hz*
- *5 channels at 150Hz*
- *8 channels at 60 Hz*
- *2 groups of 8-128 expansion channels each measured at 1/8 of the base rate*
- *frequency channels at 200 Hz*

Data filtering

- *User-selected*
- *8 levels of 4 pole filters*

I/O

- *On-board barometric pressure transducer with signal conditioning*
- *Sensor inputs*

  - analog: up to 269 analog voltage channels (WinDyn V 1.12 limit to 70 channels)

  - frequency: up to 4 mag/TTL frequency channels (WinDyn V 1.12 limit to 6 channels)

  - inductive, capacitive, or coil primary spark pick-up signal circuit

  - photo tach input circuit
- *Other input/outputs*

  -6 RS232, RS422, RS485, J1708 serial ports

- *8 digital inputs*

- *Outputs*
  - *8 relay-capable digital outputs*
- *LCD Display drivers*
  - *serial port for up to 4 LCD boards with 2 six-character LCD's each, daisy-chained*
- *4 Controller interfaces, Steppers,EC, 4-20 ma, 0-10VDC*
  - *1 RS-232 serial port*
  - *8 TPU lines*
  - *3 analog feedback signals*

Safeties (not implemented on standard Auto Dyn systems)

- Emergency Stop command (EMS) scanned at 150 Hz

- Loop of series-connected, normally closed switches for external panic buttons

- Internal loop for panic buttons on SF equipment

- 4 digital inputs configurable for Normally Open (NO), Normally Closed (NC), or TTL input

- one DPDT relay output supplies the EMS signal to external devices

Power supply

- *Type: ATX*
- *115/230 VAC, 6/3 Amps*
- *50/60 Hz*

SF-1942/2060 board-set based systems on some older systems

Processors

- *A Processor (1942 board):*
  - *MC 68332 microcontroller*
  - *On-board memory:*

    256k SuperOS ROM

    512x16 serial EEPROM

    512 k FLASH for application program

    256 k battery backed SRAM

    up to 8 MB 72-pin SIMM DRAM

- *B Processor (1942 board):*
  - *MC 68332 microcontroller*

- *On-board memory:*

  256k system ROM

  256 k battery backed SRAM

  512k FLASH

- *Clock speed 16.78 MHz*
- *16k Dual port RAM interface*

Network communication

- *IEEE 802.3 MAC Network controller with 10-Base-2 and 10-Base-T Ethernet interface*
- *NetBEUI protocol*
- *16k Dual port RAM interface*

Data acquisition

- *6 programmable gain amplifiers*
- *8-channel, 12 bit serial interfaced Analog to Digital Converter (ADC)*

Data acquisition rate

- *Base rate: 1 kHz*
- *5 channels at 1 kHz*
- *8 channels at 312 Hz*
- *2 groups of 8-128 expansion channels each measured at 1/8 – 1/128 of the base rate*
- *frequency channels at 200 Hz*

Data filtering

- *User-selected*
- *8 filter levels*

I/O

- *On-board barometric pressure transducer with signal conditioning*
- *Sensor inputs*

  - analog: up to 269 analog voltage channels (WinDyn V 1.12 limit to 70 channels)

  - frequency: up to 11 mag/TTL frequency channels (WinDyn V 1.12 limit to 6 channels)

  - inductive, capacitive, or coil primary spark pick-up signal circuit

  - photo tach input circuit

  - input for 2-channel quadrature encoder or additional TTL frequency channel

- *Other inputs*

  - 4 RS232 serial ports

  - 6 digital inputs

- *Outputs*

  - 8x8-bits DAC

  - 8 relay-capable digital outputs

- *LCD Display drivers*

  - serial port for up to 4 LCD boards with 2 six-character LCD's each, daisy-chained

- *Controller interface*

  - 1 RS-232 serial port

  - 16 TPU lines

  - 2x12-bits DAC outputs

  - 3 analog feedback signals

Safeties (not implemented on standard AutoDyn systems)

- EMS (Emergency Stop command) scanned at 150 Hz

- Loop of series-connected, normally closed switches for external panic buttons

- Internal loop for panic buttons on SF equipment

- 4 digital inputs configurable for Normally Open (NO), Normally Closed (NC), or TTL input

- one DPDT relay output supplies the EMS signal to external devices

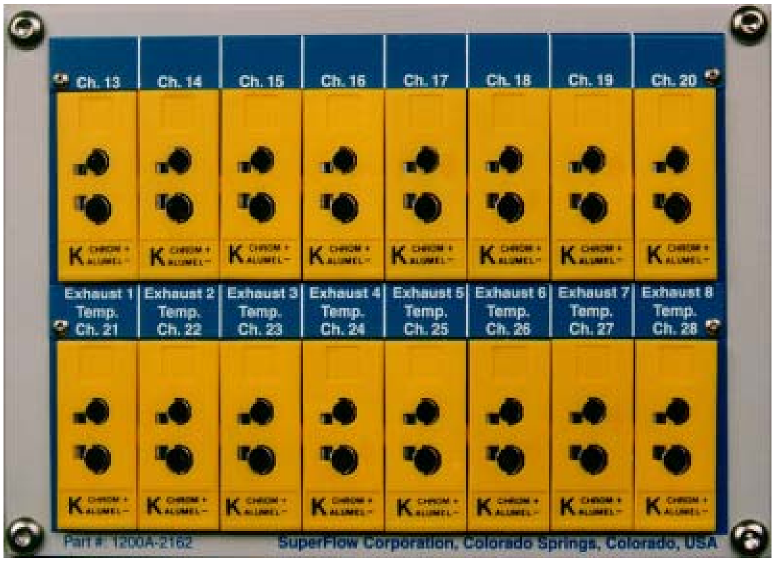
Power supply

- *Type: AT*
- *115/230 VAC, 6/3 Amps*
- *50/60 Hz*

Available sensor panels

thermocouple input panel

- *16 channels*
- *type K, ungrounded*
- *universal panel jacks, accept both standard and miniature connectors*



pressure input panel

- *10 channels*
- *up to 6 pcb-mounted transducers (of which max. 2 differential sensors)*
- *up to 4 screw-in industrial-grade transducers*
- *1/8 x #4 male fittings for pressure lines*

analog input panel

- *8 channels*
- *4.096VDC, 5 VDC, 10 VDC excitation voltages*
- *+/- 5 VDC and +/- 12 VDC supply voltages*
- *configurable gain and offset, accepts any analog voltage between –100 and +100 VDC*
- *color-coded and keyed 10-pin Lemo connectors*

system interconnect panel

- *handheld controller serial port*
- *air and fuel sensor frequency inputs*
- *air humidity and temperature analog inputs*
- *optical tachometer input*
- *spark clip frequency input*
- *color-coded and keyed 10-pin Lemo connectors*

3

Packaging and Handling

3. Packaging and Handling

3.1. Weights

Component	Net weight
SF-815 dynamometer frame	5600 lbs. / 2550 kg
SF-835 dynamometer frame	6000 lbs. / 2730 kg
SF-845 dynamometer frame (with absorber)	6650 lbs. / 3000 kg
SF-875 dynamometer frame (with absorbers)	11,000 lbs. / 5000 kg
SF-880 dynamometer frame (with absorber)	12,000 lbs. / 5500 kg
Absorber module, single E/C	590 lbs. / 270 kg
Absorber module, dual E/C	1140 lbs. / 520 kg
Sensor box with stand, Basic, Sport, or Expert	40 lbs. / 18 kg
Sensor box with stand, Pro	50 lbs. / 23 kg
Computer package (optional)	110 lbs. / 50 kg
Accessory box (includes sensor box)*	60~80 lbs. / 27~36 kg

* exact weight depends on the model and configuration

3.2. Shipping dimensions

Component	LxWxH
Rollset	91”x51”x58” (231x130x147 cm)
Absorber module, single E/C	
Absorber module, dual E/C	
Absorber module, water brake	
Computer package (optional)	
Accessory box (includes sensor box)*	

3.3. Lifting and handling instructions

3.3.1. Main dynamometer frame

The main dynamometer frame can be lifted by forklift or crane. An 8000 lbs. (4000 kg) lifting capacity is required.

Lifting holes are provided on the inside of the dynamometer frame. Remove the cover between the rolls to access those lifting holes. The holes are located in the bulkheads, next to the rolls.

WARNING Lifting the dynamometer with the forks only partially engaged in the slots may result in tipping and falling of the dynamometer, resulting in damage, severe injury, or death. Use extreme caution when moving heavy equipment.

WARNING If the dynamometer is lifted with the absorber module attached, the frame may tip over. Use an additional lifting sling around the absorber module.

3.3.2. Absorber module

The absorber module is shipped on a pallet. It can be lifted with a forklift or pallet jack.

3.4. Packaging of the AutoDyn

Following list can be used as a check sheet when your AutoDyn arrives.

1. One dynamometer mounted in a wooden frame. The dynamometer is shrink-wrapped and secured by metal straps.
This package includes:

1.1. the main dynamometer frame

1.2. the calibration arm assembly (models with truck axle only)

1.3. the vehicle restraint bars (set of 3)

2. One absorber module mounted on a pallet. The absorber module is shrink-wrapped and secured by metal straps.
This package includes:

2.1. the absorber module

2.2. the drive-shaft

3. One 32”x24”x17” (81x61x43 cm) carton on a separate pallet.
This includes:

3.1. the sensor box

3.2. an accessory box containing:

3.2.1. the handheld controller

3.2.2. all sensors, accessory cables, and mounting hardware

3.2.3. the manual, software disks, and a system calibration envelope (in a sealed plastic bag)

3.2.4. 1 AutoDyn video tape

3.2.5. 2 WinDyn video tapes

NOTE If an (optional) computer package is supplied, the 32x24x17 carton and the computer, monitor, and printer may all be shipped inside a large box on a pallet.

3.4.1. Order of unpacking and inspection

NOTE These unpacking and inspection instructions should be used if you are checking the delivery of the goods without proceeding with the actual installation.
If the dynamometer can be installed immediately in its final location, see also “Installation” (Section 3) of the AutoDyn manual.

1. Cut the straps securing the calibration arm and restraint bars onto the main dynamometer frame and remove these from the frame. Inspect the dynamometer for any external damage.

2. Unwrap all the removed parts and inspect them for damage

WARNING The cover is heavy and may fall inside the dynamometer. Be careful when removing it.

3. Remove the screws securing the cover between the rolls. Lift the cover and inspect the inside of the dynamometer for apparent damage.

4. Rotate the rolls. They will feel heavy but should rotate freely.

5. Cut the straps securing the absorber module and remove the packing material. Inspect the module for damage.

6. Open the accessory box and carefully remove and unwrap the sensor box and all other parts. Inspect them for damage.

7. Locate the key for the sensor box door. Open the sensor box and inspect the inside for any loose parts.

8. Locate your manual and read the “System overview” and “Installation” sections for installation information.

NOTE If there is any shipping damage to report, note it on the shipping receipt and notify SuperFlow immediately.

4

Test Area Requirements

4. Test Area Requirements

4.1. General requirements

There are many possible facility requirements and room layouts for a chassis dynamometer. Testing needs vary from basic power runs to extensive R&D to mileage accumulation, with power levels ranging anywhere from 50 to 1000+ HP. It is not possible to recommend a generic design which will fit every customer's needs and budget. These instructions merely attempt to point out the issues you need to be aware of when designing and building your facility. There are four general categories of such issues:

1. room issues
2. safety / environmental issues
3. technical issues
4. convenience issues

In all cases, you should consult with your architect, contractor, mechanical and electrical engineers, and with city planning and regional building offices. Your SuperFlow Sales Associate or Customer Service representative will be happy to assist you with general design advice; however, they cannot reasonably be expected to provide detailed engineering services for each facility.

4.2. Room

4.2.1. Room size

The dynamometer room should be at least 12' (3.6 m) wide, 26' (8 m) long, and 8 to10' (3 m) high. The larger the room, the more expensive the construction, and the more difficult it is to achieve significant ventilation air speeds. A larger room will however have greater thermal mass and is easier to maintain at a constant temperature.

Your room should be large enough to comfortably accommodate your vehicles and accomplish your tests, but not much larger.

You will need to determine if you prefer a pit-mounted or a surface-mounted dynamometer, and evaluate the resulting lift and platform requirements, or the pit size. SuperFlow has typical pit drawings available. They are included at the end of this section. For surface-mounted dynamometers, a platform kit is also available.

The AutoDyn design is essentially uni-directional , although opposite rotation is possible without negative consequences. The position of the dynamometer in the room depends on the requirement to test either rear-wheel drive (RWD) or front-wheel drive (FWD) vehicles. If both RWD and FWD vehicles will commonly be tested, the room should be longer to accommodate both, while maintaining the same direction of rotation on the dynamometer. If your room size and dynamometer positioning requires turning the vehicle around for testing either RWD or FWD, then you should be aware of the difficulties this will cause to ventilate the room, cool the vehicle, and evacuate the exhaust.

For convenience and safety, a separate control room (at least 8' (2.4 m) long by 6' (1.8 m) wide), overlooking the dynamometer area, is recommended. This room houses the computer and printer and provides a convenient viewing area during testing.

4.2.2. Room positioning

A chassis dynamometer represents a significant investment. Unless secrecy of your development programs is an important issue, it may be to your advantage to create high visibility of the dynamometer by positioning it within view of customers in the reception area of your facility.

In all cases, vehicle and operator access to the dynamometer area and dynamometer itself must be easy. Many high performance or racing vehicles have limited ground clearance and turning radius. Ramps or tight turns may cause problems.

The dynamometer area must be separated and well insulated from the rest of your facility to avoid noise and fume problems. Positioning the dynamometer next to an exterior wall also may reduce the cost of air handling systems.

Finally, wherever possible the dynamometer should be positioned so that exhaust extraction systems can be directed away from other nearby buildings, to minimize noise impact on your neighbors.

4.2.3. Room layout

The position of the dynamometer in the room must take into consideration the type of vehicles which will be tested (FWD and/or RWD) as well as their size and tie-down requirements. As discussed in the "Theory of testing" section, tire losses increase with downforce. To minimize downforce while applying adequate vehicle holding force, tie-down straps should be fairly horizontal. This means the tie-down hooks must be installed away from the vehicle. Make sure the dynamometer is positioned to allow for this distance.

If present, the control room must be positioned for easy access from the dynamometer room and optimum viewing of the vehicle and operator. Avoid positioning the control room where failure of a mechanical part on the vehicle may create a hazard.

Floor strength should be considered. The AutoDyn weighs between 5500 and 13,000 lbs, depending on the model. Add the weight on the driven axle of the vehicle for total floor load. The AutoDyn is supported 8 to 20 points. In some cases, the floor will have to be reinforced to support this pressure. A 4" to 6" (10 to 15 cm) reinforced concrete slab of 4000 psi (280 kg/cm^2) is adequate.

For reasons outlined above, the control room should have a large window to the dynamometer area. A window to the workshop and possibly to a customer viewing area may be desirable, and in some cases, even required by employee safety regulations.

There should be separate vehicle access and personnel doors for safety.

The room layout must have provisions for room ventilation, vehicle cooling blower(s), exhaust extraction, and (where applicable) the differential oil cooler.

For safety and environmental reasons, it is generally not recommended to provide a workspace inside the dynamometer room, but cabinets are a good idea to store dynamometer accessories and ancillary equipment.

Finally, a chassis dynamometer room can quickly accumulate dirt from the test vehicles. Floor maintenance should be considered in the room layout. An appropriate floor drain is recommended; this drain should be routed to an oil separator.

4.3. Safety and environmental issues

4.3.1. Safety

Testing vehicles at high speed and power levels is hazardous. The room construction and layout should provide optimal safety to the vehicle operator and to bystanders. The first rule for safety is to prevent room access to personnel (other than the operator) during testing. Install warning lights and signs to this effect. Make sure there is good visibility all around the room. This includes good lighting and the installation of wide-field mirrors so the operator can see all areas of the cell from the driver's seat of the test vehicle.

If projections from the tires could cause damage or a hazard, install adequate shields. In all cases, barriers or guards should be installed around the vehicle test area to prevent contact with rotating tires or dynamometer rolls.

Personnel doors should be escape doors, opening outwards from the cell. Proper fire fighting equipment must be available (fire blanket, extinguishers). An industrial-quality CO monitor is recommended.

WARNING if your dynamometer is installed in a pit, poisonous CO gas will tend to accumulate in the pit. Provide forced pit ventilation before any intervention on the dynamometer inside the pit!

All electrical outlets in the dynamometer room should be protected by a Ground Fault Interrupt (GFI) circuit.

4.3.2. Environmental

The installation of a dynamometer test cell normally requires permits. You will have to contact local zoning, building, and environmental authorities. You should expect having to comply with regulations for noise control, pollution (exhaust gas), fire hazard, and employee safety.

cleaning. An epoxy paint mixed with an abrasive material is commonly used.

4.4. Technical issues

4.4.1. Problem statement

The two major problems you will face in a chassis dynamometer test room are heat evacuation and exhaust gas extraction.

All power generated by the engine will be converted to heat: in the engine cooling system(s), engine compartment, vehicle transmission and exhaust system, and in the dynamometer itself.

4.4.2. Air supply

Chassis dynamometer testing produces a lot of heat. This heat is for the most part released to the test room air. Significant ventilation is required to evacuate this heat from the room. If the room temperature increases during the test, or exhaust gas recirculates into the engine inlet, your test results will vary in an unpredictable manner. Both the quantity and the direction of air flow are critical for repeatable test results.

The tables at the end of this section provide some examples of estimated cooling requirements as a function of engine power.

The fan(s) you select must be able to generate the required airflow at the pressure drop caused by your inlet and outlet ducting. Keeping the length and complexity of ducting to a minimum greatly reduces the pressure drop and thus the fan power required. Axial fans are most effective for high airflow at low pressure drops. The fan(s) are best installed on the outlet side. This way, a slight negative pressure (about 0.5 to 1 inH_2O or 100 to 200 Pa) is maintained in the test room; this prevents noxious fumes from entering the rest of the building.

A cross-flow design is recommended for the ventilation system. The air inlet should draw fresh air from outside the building, and should be positioned away from the air outlet, to prevent air recycling. If engines will be tested without air filter, appropriate air filters should be installed on the inlet ducts. We recommend 92% efficient filters. In that case, it is best to provide a pressure manometer across the filters; once the filters become clogged, the ventilation system may not be able to overcome the pressure drop and the air flow through the room will rapidly decrease.

For pit installations of an Eddy Current dynamometer, a 24” (60 cm) or larger duct with a suitable blower should be provided for adequate absorber cooling air supply.

The large fans required to provide the necessary airflow are noisy. They should be installed in a location where the noise causes minimal disturbances for your employees and neighbors. Additional protective measures may have to be taken, such as enclosing the fans and ducts in sound-dampening material.

We recommend shutters on the air inlets and outlets so the room may be sealed off to prevent freezing in cold climates.

4.4.3. Vehicle cooling

The heat released by the vehicle cooling system, engine block, transmission, and exhaust, should be evacuated by the main room ventilation system. In many cases, the airflow patterns resulting from the room ventilation system do not provide adequate cooling of certain vehicle components. The vehicle cooling system, engine compartment, and exhaust system, are usually the most troublesome areas. To compensate for this deficiency, spot cooling fans are recommended. Although these fans do not increase the overall airflow through the room, they modify the local patterns and speeds of the airflow to accomplish specific goals. High speed fans are commonly used for these tasks. Some racing vehicles require air speed through the radiator at near road-speed. Achieving high flows at high speeds requires tremendous power. This explains why many high-performance chassis dyno rooms resemble wind tunnels, with fans of several hundred horsepower. As an example, to achieve 200-mph (320 km/h) air through a radiator cooling a 1000 HP (750 kW) engine at WOT, the electrical power for the fan exceeds 300 HP (220 kW)!

If your requirements do not quite reach these levels, you should purchase a couple of mobile high-speed fans of 5000-10000 cfm (8500-17000 m3/hr), which can be positioned in critical areas.

The chart below shows the pressure required to achieve a certain air speed.

Air Flow Velocity vs Test Pressure				
Air Pressure		Air Speed		
inH2O	Pa	Ft/s	mph	km/h
0	0	0	0	0
1	249	66	45.1	72.2
2	498	94	63.8	102.1
3	747	115	78.2	125.1
4	996	132	90.3	144.4
5	1246	148	100.9	161.5
6	1495	162	110.6	176.9
7	1744	175	119.4	191.1
8	1993	187	127.7	204.3
9	2242	199	135.4	216.7
10	2491	209	142.7	228.4
11	2740	220	149.7	239.5
12	2989	229	156.4	250.2
13	3238	239	162.7	260.4
14	3487	248	168.9	270.2
15	3737	256	174.8	279.7
16	3986	265	180.5	288.9
17	4235	273	186.1	297.8
18	4484	281	191.5	306.4
19	4733	289	196.7	314.8
20	4982	296	201.9	323.0

Only centrifugal fans are capable of providing the pressures needed for high speeds.

4.4.4. Exhaust extraction

In addition to noxious gases, a significant amount of heat is released through the exhaust system. A proper exhaust extraction system is critical for the safety of your employees inside and outside the test room.

The exhaust system should be able to handle both the flow and the temperature of the exhaust gas. Most ventilation ducts and fans only handle temperatures up to 250 degF (110 degC). It is easier to design a system for higher flows than one for higher temperatures, so exhaust gas is generally diluted with ambient air. For best results, the dilution ratio should be somewhere between 2 and 4.

As with spot cooling fans, the exhaust fan is usually a high-speed fan of the centrifugal type. Proper temperature-resistant ducting should be installed to capture the exhaust gas close to the vehicle tailpipe. Do not seal the duct to the tailpipe: this would prevent dilution of the exhaust gas with ambient air and would also influence engine performance by reducing the exhaust back-pressure. There should be enough free area

4.4.6. Compressed air supply

The dynamometer rollset is equipped with roll locks that are actuated with compressed air.

A compressed air supply pressure of 90-100 psi (620-690 kPa) is required.

It is recommended to provide a safety shut-off valve for the air supply in case of a fire.

4.4.7. Electrical power

Do not underestimate the total amount of electrical power required to supply the test room services. Electrical power is required for:

- the eddy current power absorber(s) (SF-830 and SF-840 only)
- cell ventilation fan(s)
- exhaust extraction fan(s)
- spot cooling blower(s)
- cooling tower fan(s) (SF-850 only)
- control electronics and computer system
- space heaters and air conditioning units (when needed)
- test room lights and accessory outlets

The tables at the end of this section provide some examples of the power required for the room services. A separate circuit (with surge protection and uninterruptible power supply (UPS) if possible) is recommended for the control electronics and computer system. Contact your electrician for detailed installation advice.

4.4.8. cell controls and monitoring

Controls must be provided for ventilation and exhaust systems, water system, safety shut-off valves, fire warning and protection system, and basic cell services such as room lights, warning lights, and door controls. It is generally a good idea to centralize controls on a control panel in the control room, and mirror this panel inside the test room.

It is also recommended to install a pressure manometer in the test room to detect abnormal pressure drops in the room ventilation system (e.g. due to clogged filters or closed shutters).

4.4.9. Convenience issues

Based on experience gathered installing and visiting countless test facilities, we suggest following enhancements to your facility:

- wireless two-way communication link between driver and system operator
- intercom between test room and control room
- digital camera for pictures of the test vehicle. Such

pictures can be downloaded to the test system PC for display and storage with the test data files. Additionally, pictures provide a quick method to record the configuration of the vehicle and the cooling blower arrangement for the test, improving test repeatability.

- closed-circuit video with monitor in the control room (and/or in the customer viewing area)
- microphone in the test room, driving speakers in the control room. Due to the noise insulation of the test room, it may be difficult to hear abnormal engine or driveline sounds from the control room.
- dedicated telephone / modem line for the test system computer, for troubleshooting and/or electronic communication purposes. A wireless telephone is convenient.
- additional test system PC monitor in the customer viewing area, if separate from the control room (e.g. the lobby of your facility). It may be a good idea to provide a cable for this purpose when building your facility.
- battery-powered emergency lighting in test room and control room
- space heater in the test room and air conditioning in the control room, depending on your climate
- a secure storage space in the control room, for software, manuals, back-up disks, and test results; also a closed storage space in the test room for sensors, cables, calibration equipment, and personal protective equipment (such as earmuffs and safety glasses).
- wall-mounted brackets for the vehicle tie-down straps

We also recommend to keep the test room clean at all times. Dirt from the test vehicles will tend to accumulate; the powerful room ventilation systems will cause any dirt, rags, papers, etc. to be swept up and blown around. Protect your engine, vehicle, and fans, by avoiding loose objects. Clean test vehicles before installing them on the dynamometer whenever possible. Install a hose bib and garden hose for periodic wash-down of your test room.

4.5. Further reading

An excellent book on the design of test facilities and the testing of engines is:

Engine Testing – Theory and Practice, by Michael Plint and Anthony Martyr, Butterworth-Heinemann, Oxford, UK, 1995. ISBN 0 7506 1668 7

4.6. Sample testcell calculations

On the next four pages, we provide typical test cell services calculations for a 400 HP (300 kw) vehicle on an EC dynamometer and for a 750 HP (550 kw) vehicle on a hydraulic dynamometer. Ask your Sales or Service representative for a printout of recommended test cell services for your applications.

4.7. Installation drawings

Drawings are available for pit installations and for the platform and lift kit available from SuperFlow.

5

Installation

5. Installation

5.1. Connections

5.1.1. Unpacking

WARNING The AutoDyn is very heavy. All lifting and handling should use standard safety procedures for heavy objects. The forklift must be rated for at least 8000 lbs. (3650 kg).

1. Depending on how the dynamometer was shipped to your facility, it may arrive with or without a crate. Taking care not to damage the paint, remove any crating and other packing material from the dynamometer. Inspect the dynamometer for any exterior damage.
2. Remove the packing from the absorber module (if supplied), and inspect the module for damage.
3. Remove the packing from all the other equipment and lay out the parts. Inspect the equipment for any damage.

5.1.2. Installation

1. Be sure to think about access to the area and about the maneuvering space required for moving a vehicle onto the dynamometer, ramp, or lift.
2. Position the dynamometer in the desired location. The floor or pit must be level and be able to support the weight of the dynamometer, lift, and vehicle.
3. Level the dynamometer using the leveling screws in all four corners.
4. Remove the four screws securing the central cover (between the rolls).

WARNING The cover is heavy. Use caution when removing it and make sure it does not drop into the dynamometer housing.
Remove the cover.

5. Remove the metal shipping strap from the load cell bolts and install the load cell. (The load cell may already be installed on your system.)
6. Attach the absorber module to the dynamometer frame as described below.
   If you do not have an absorber module, skip to step 7.

6.1. Single EC absorber module

6.1.1. Connect the drive shaft to the differential.

6.1.2. Connect the absorber module to the dynamometer as shown.

6.1.3. Connect the drive-shaft to the absorber.

6.1.4. Connect the absorber controller cable to the “control signal” plug on the dynamometer connection panel

6.1.5. Connect the absorber power supply cable to a 240V single phase outlet with a 20A rating

6.2. Dual EC absorber module

6.2.1. Connect the drive shaft to the differential.

6.2.2. Connect the absorber module to the dynamometer as shown.

6.2.3. Connect the drive-shaft to the absorber.

6.2.4. Connect the absorber controller cable to the “control signal” plug on the dynamometer connection panel

6.2.5. Connect the absorber power supply cable to a 240V single phase outlet with a 40A rating

7. Surface mounted dynamometer installations only: install the three vehicle restraint bars at the rear of the dynamometer (side opposite the dynamometer connection panel).

8. Install the air pressure supply line (100 psi / 690 kPa max.) to the roll brakes using the quick connect fitting at the dynamometer connection panel.

9. Install and secure the ramp, lift, platform, and/or cover plates.

1. Position or attach the module in a suitable location.
2. Connect the cooling lines to the quick connect couplings on the dynamometer.
3. Connect the power supply cable to a suitable 115/230VAC outlet.
4. Connect the cooling hoses to the dynamometer water system as shown.

5.1.3. Sensor Box Installation

Locate the sensor box stand. This stand is shipped as three components:

- the pole
- the base with casters
- the ring

Slide the ring onto the pole; the flat side of the ring should be towards the sensor box mounting plate, do not tighten the ring yet.

Insert the pole into the base with casters.

Bolt the sensor box onto the mounting plate on top of the pole (4 bolts).

Slide the ring to a comfortable grabbing height, typically about 4~6 inches (10~15 cm) below the bottom of the sensor box and secure the ring with the set screw.

Verify that the cable hooks are installed on the bottom of the back of the sensor box and that the two bolts are tight.

WARNING Do not connect the sensor box power cable until all steps are complete to 5.1.6.

The sensor box electrical cable which plugs into the bottom of the sensor box must be connected to the "control box" plug on the dynamometer connection panel.

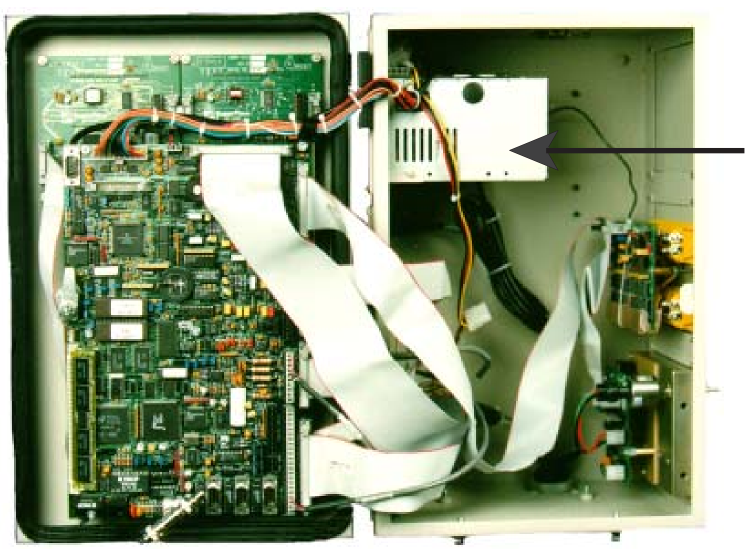
5.1.4. Sensor Box Power

Do not connect the sensor box power yet.

The sensor box power input is selectable for 120VAC or 240VAC. The frequency can be 50 to 60 hertz.

Verify the voltage selector switch setting on the power supply inside the sensor box:

Remove the 4" hex buttonhead screws attaching the panel with the AC Power plug to the sensor box and slide out the power supply about 1 1/2" (3 cm) until the red switch is visible. Check the switch setting.



Power Supply

- *Other models:* open the sensor box door using the special key. The black selector switch is visible on the front of the power supply. Check the switch voltage setting.

NOTE The power supply used on the latest models is a standard PC power supply of the ATX type. The power supply used in older models is a standard PC power supply of the AT type. Voltage checkpoints for both power supplies are provided on labels affixed to their case.

5.1.5. Handheld Display Connection

Be sure the sensor box power is turned OFF. The Handheld Control unit plugs into the **brown** receptacle on the Connector Panel on the Sensor Box. The Handheld connector plug is color coded and keyed for ease of identification. Connect the sensor box power cord to an AC outlet and turn on the white power switch. The sensor box LCD display and the Handheld Controller should now display information.

5.1.6. General check

1. If installed, check the tightness of the absorber module to roll module hardware and the driveshaft screws.
2. Install the center cover on the dynamometer.
3. Install the cover on the absorber housing (if available).
4. Verify that all fasteners on the dynamometer covers are tight.

Your AutoDyn dynamometer is now operational. Further sections in this installation guide will address sensor installation and computer setup instruction.

5.1.7. Humidity and Temperature Probe

Be sure to have the sensor box power turned OFF. The humidity and air temperature probe plugs into the upper **blue** receptacle on the Sensor Box Connector Panel. The humidity sensor is sensitive to contamination, so it should be placed in a fresh air stream and away from potential engine oil, gasoline, and exhaust spray.

5.1.8. Thermocouple Connections

The Sensor Box has inputs for up to 16 type K thermocouples. Provided with the system are two open tip thermocouples and two closed tip thermocouples*. The open tip thermocouples have a faster response time due to the smaller mass. These are typically used for exhaust gas temperature measurement. The closed tip thermocouples are typically used for fluid measurement. Plug the thermocouple into the extension cable (if needed) or directly into the thermocouple panel. The channel will now produce a reading. This reading will be recorded during any test or when manually recording data.

*Depending on configuration

5.1.9. Pressure Connections

The Sensor Box has inputs, depending on configuration, for oil pressure, manifold air pressure, and inlet air pressure. Simply connect the #4 hose to the appropriate pressure.

5.1.10. Optical Wheel Tach Connection

An Optical Wheel Tach sensor can be installed to read rear wheel slippage. The sensor plugs into the 1200A-1936 Sensor Box Connector Panel. Be sure to have the power turned OFF before plugging in the connector. Insert the connector into the **yellow** receptacle. Apply a small piece of the supplied reflective surface tape to the rear wheel. Mount the optical pickup rigidly so that you can receive a good signal. Shield the tape from bright ambient light.

5.1.11. Ignition Pick-up Connection

The ignition pick-up plugs into the 1200A-1936 Sensor Box Connector Panel. Be sure to have the power turned OFF before plugging in the connector. Insert the connector into the **upper green** receptacle.

5.1.12. Air and Fuel Sensor Connection

Air flow and fuel flow measurement turbines can be connected to the 1200A-1936 Sensor Box Connector Panel. Be sure to have the power turned OFF before plugging in the connector. A Y-cable is used to allow connection of the standard sensor AMP plugs to the connector panel. Insert the connector into the **red** receptacle.

5.1.13. Remote Switch, Aux 1, Aux 2, Aux 3, and Control Inputs Connections

These receptacles (**black, gray, lower blue, white, and lower green**) are not used in the standard version of the AutoDyn dynamometer.

5.2. Configuration

5.2.1. Computer Communication

The Sensor Box communicates with a computer using a LAN connection. This is an acronym for Local Area Network. This is an Ethernet network connection and you will need a network card in your personal computer.

The system comes from SuperFlow configured for 10Base-T.

If 10Base-T is used, it will be connected to the P3 RJ-45 connector on the side of the Sensor Box.

5.2.2. Computer Setup

SuperFlow has provided a CD disk that contains the **WinDyn**™ operating system. From Windows®, run **setup**. Follow the **Setup Wizard** steps to properly install your software. If you are unfamiliar with Windows® or Networks, SuperFlow strongly recommends that you have this done professionally. The installation of WinDyn™ is typical of any pro-gram installation, however the Network configurations MUST be done properly. If the Network is not running correctly, you will NOT be able to receive data from the Sensor Box.

Note that the following instructions are necessarily vague. This is because of the variability in computer hardware/software in the PC computer industry. The fundamental requirements are:

1. The computer and the sensor box must be properly connected to each other using 10baseT Ethernet cable.

2. The computer must be running Windows 3.1, Windows95, Windows 98, Windows XP, Windows NT, or Windows 2000.

3. The computer must have NetBEUI installed and selected as the default protocol. These instructions assume that you will be using 10base-T and running Windows XP.

5.2.2.1. Install network card

With the computer off, install a 10base-T network card with a CAT5 connector on it into the computer. Follow the instructions that came with the network card for installation. We suggest using a PCI network interface card.

5.2.2.2. Install network cable

The sensor box systems are typically shipped for use with 10base-T cable. Connect a length CAT 5 cable from the CAT5 connector of the sensor box to the network card installed in your computer.

MDI/MDIX network cabling

Networks using 10Base-T cabling are typically connected using a 'star' topology, with a hub at the center of the star. Each device is then connected to the hub using a length of 10Base-T cable.

If the network consists of only two devices (for example a sensor box and a computer), the hub can be eliminated from the network by connecting them together using an CAT5 cable.

5.2.2.3. Configure PC for NetBEUI communications

If your computer was supplied or up-dated by SuperFlow, all of the setup operations described below should already be done.

If your computer is running Windows XP or 2000, the NetBUI protcol will be installed automatically by the WinDyn disk. Jump to 5.2.2.5.

For all other Windows systems, turn on the computer and select **Start|Settings|Control Panel**.

Double-click on the **Network** icon.

If NetBEUI is not listed:

- Click **Add**,
- Click **Protocol**
- Click **Microsoft** from the **Manufacturers** list
- Click **NetBEUI** from the **Network Protocols** list
- Click **OK** and follow the on-screen instructions

If more than one protocol is listed:

- **Select** NetBEUI
- **Click on** Properties
- **Click on the** Advanced **tab**
- **In the lower-left corner, place a checkmark in** Set this protocol to be the default protocol
- **Select** OK **to dismiss the** NetBEUI Properties **dialog box**
- **Select** OK **to dismiss the** Network **dialog box**

5.2.2.4. Install WinDyn

- **Insert disk 1 into the computer**
- **Select** Start|Run
- **Enter** a:setup.exe **(assuming the disk was inserted in drive a:)**
- **Follow on-screen instructions**

5.2.2.5. Run WinDyn

You should now be able to run WinDyn by double-clicking its icon, or by selecting it from the **Programs|SuperFlow WinDyn** menu.

Selecting the LAN Adapter

To communicate on the network, the SuperFlow WComNet program needs to know which computer LAN adapter to use. This issue is somewhat complicated by the fact that Windows95 and WindowsNT will assign LAN adapter numbers to the various communications protocols which are capable of carrying NETBIOS frames. There is no way for the software to know which LAN adapter number corresponds to the NetBEUI protocol required for communication to the SuperFlow dynamometer system.

The default LAN adapter is set to LAN adapter 0 (Lana 0). If you find that you cannot connect with the dynamometer system using this default setting, you may need to select a different LAN adapter number.

A utility has been included as part of the WComNet program to aid in selecting the appropriate LAN adapter. This utility is accessed by selecting Configure|Lan Adapter from WComNet's main menu.

Follow the following steps to select the appropriate LAN adapter:

1. Make sure that the dynamometer system is turned on and connected to the network interface card in the computer.
2. Open the LAN adapter setup utility by selecting Configure|Lan Adapter from the main menu.
3. Select a LAN adapter number by clicking on the corresponding radio button.
4. Click on the Test button to see if WCOMNET can connect to the dynamometer system.
5. If Comm Status in the main window changes to "Connected", you have found the correct LAN adapter number and you are done (select the Done button). If Comm Status still displays "Disconnected", select the next LAN adapter number and click on the Test button again. Repeat this process until the correct LAN adapter number is found.
6. If you still cannot connect to the dynamometer system, then the problem lies elsewhere. Check that the cables are hooked up (also inside the sensor box), and that they are making good connection. Make sure that the dynamometer system is turned on, that the

network names are correct, and that the NetBEUI protocol is bound to your installed network interface card.

If you cannot get WinDyn to communicate with the sensor box, contact a SF customer service engineer for assistance

5.2.2.6. How to configure your system for US units or Metric units

The AutoDyn is completely configured by software. At the time of installation of WinDyn on your PC, you will be asked to select the language and units system of your choice. The configuration files appropriate for these selections will then be installed in the main system directories. Other configuration files will be copied to inactive directories.

We have made the selection of "appropriate configuration files" based on the most common combinations of languages and units systems. You will find that following configuration choices are available as standard:

Language	Units
English	US
English	Metric
Dutch	Metric
French	Metric
Spanish	Metric
German	Metric
Italian	Metric
Swedish	Metric

The Units system is applied consistently. This means US unit configurations will use all Imperial units and Metric unit configurations will use all S.I. units.

Changing from one units system to the other or from one language to another is possible by simply loading the appropriate Test Group. This Test Group will load configurations and screens as appropriate.

NOTE The system configuration files are essential to the operation of the system and most of the other files (such as display files, test files, limits files, etc.) are linked to specific configuration files. To avoid selecting incompatible files, we recommend the use of the "Test Group" function which automatically loads compatible files. Refer to the Test Group section (Section 12.2. "Design Test Group") of the WinDyn section of this instruction manual for more details.

For specific measurements, some customers may wish to use different units than the ones defined in the default configurations.

Example*:*

metric configurations systematically use kilowatt (kW) for power, but you may wish to have horse-power (HP) instead, while keeping all other metric units.

In that case, the standard configuration file that most closely fits your requirements should be selected and then modified where desired, using the channel configuration editor. Refer to the Configuration Editor section (Section 16 “Configuration File Editor”) of the WinDyn instruction manual for detailed instructions.

NOTE Screen display files (*.CDF), Specifications files (*.CST), and Autotest files (*.TPF) are linked to specific configuration files. If you have saved a modified configuration file under a new name, you will have to rebuild those links for the screen, specifications, and test files to work with the new configuration file.

5.3. Calibration

NOTE All models are calibrated at the factory. You may wish to check the load cell calibration prior to first use of the AutoDyn. Please see Section 20. “Service and Calibration” for instructions.

6

System Operation

6 System Operation

6.1 Overview

This section will assist in setting up and running a test on a SuperFlow AutoDyn system. Follow this procedure setup for each test. Repeatable and accurate test results are obtained by consistent test methods.

Do not attempt to use the dynamometer without proper training from SuperFlow. Severe injury and/or property damage may result from improper use.

6.2 Safety

A dynamometer test cell can be a dangerous environment. The operator will be exposed to a number of hazards. These risks are generally associated with the vehicle under test rather than with the dynamometer itself and it is thus not possible for SuperFlow to protect the operator against all these hazards by the design of the dynamometer instrumentation system.

A proper test cell environment eliminates or reduces the risks associated with dynamometer testing as much as possible. Refer to the SuperFlow AutoDyn Room Requirements (available from SuperFlow Customer Service or Sales) for information on a proper test cell environment.

Examples of risks are:

- engine noise
- risk of fire due to the fuel used
- risk of burns due to hot engine and exhaust system parts
- exposure to rotating parts
- exposure to parts being projected from the vehicle during operation
- excessive exhaust gas concentrations

6.2.1 Safety Procedures

- Always strap down the vehicle. A parking brake or wheel chocks cannot safely hold the vehicle in a full load test.

- Do not use the brakes of the vehicle. Strong braking will cause the vehicle to jump backwards and may result in loss of stability or damage.

- Do not turn the steering wheel while the rolls are turning. Doing so may cause the vehicle to sway sideways off the rolls. If the front tires are on the spinning rolls, turning the steering wheel may cause a torque steer condition where the tires will go to a full lock position, left or right.
- Clear the area behind the vehicle before starting any test. Rocks or other debris may be projected from the tires and could cause bodily injury or material damage.
- Wear ear and eye protection at all times when testing.

6.2.2 Handheld stop key

To reset the system at any time or to stop a test under way, press the stop key on the handheld as shown below. This will remove the load from the dynamometer and reset the handheld to the main operation screen.

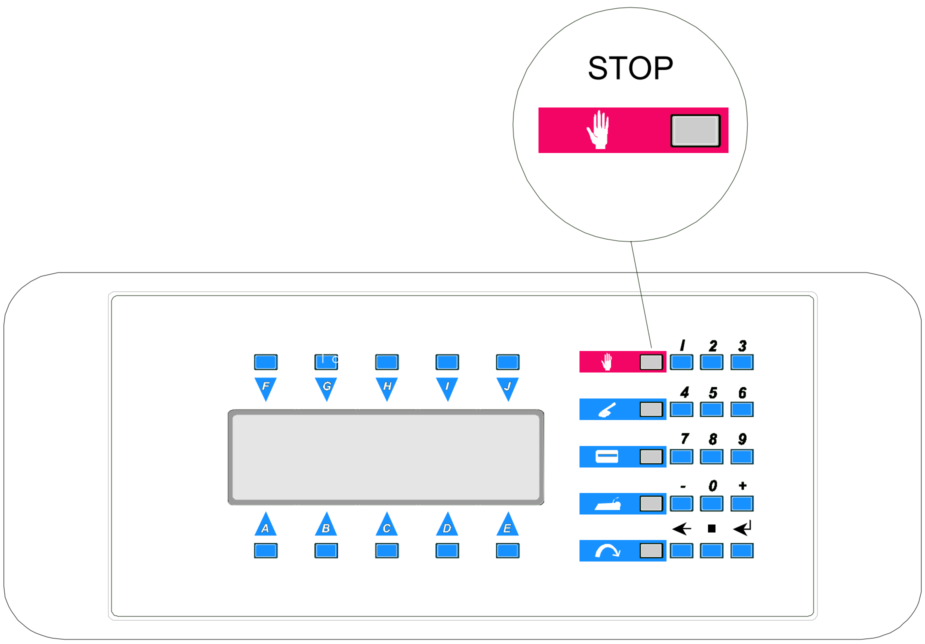


Figure 6-1 Handheld Stop Key

6.3 Preliminary checks

Both the AutoDyn and the vehicle should be checked before testing to ensure safety and accurate results. The form provided on the next page can serve as a guideline for a Pre-Test Checklist of the vehicle. System checks should be performed prior to testing.

PRE DYNO TEST CHECK LIST

Customer's Name ________________________________

Date of test ______________Time of Test ______________

______Visual Inspection of tires

______Tire Pressure ______________________

______Coolant Level

______Oil Level

______Trans Level

______Visual Inspection of Engine Bay

______Visual Inspection of suspension components

______Fire Extinguisher at right front of car

______Belts

Comments: ____

____

- Verify the air pressure to the roll lock system. The air pressure should be at least 80 psi *[550 kPa]* for adequate brake force.
- Verify the availability and condition of the tie-down straps. Do not use frayed or damaged tie-down straps.
- Verify the condition of the vehicle. Check for leaks or damage which may result in projections or fire hazards while testing. Worn tires are unsafe. Tires of different sizes (left to right) should not be used. Correct any such problems before installing the vehicle on the dynamometer.
- Verify the tire pressure and adjust as necessary. Tire pressure should be at the highest nominal cold pressure setting for the lowest tire losses on the dynamometer.
- Power on the Sensor Box and Eddy Current (if applicable).
- Power on the computer system and load WinDyn via the Desktop icon.

6.4 Vehicle installation

1. Lock the rolls using the “Roll lock” command on the handheld controller (Figure 6-2).

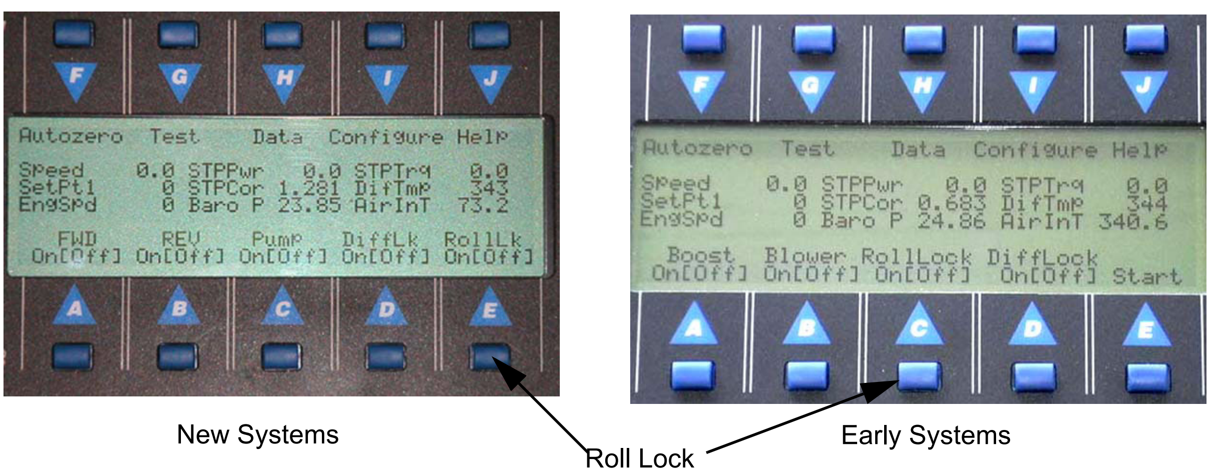


Figure 6-2 AutoDyn Main Operation Screen

2. Drive the vehicle onto the rolls with the primary drive wheels centered laterally on the surface of the roll. Set the tires slightly forward of the top but it is not necessary to be positioned very accurately at this point (Figure 6-3). Front wheel drive vehicles should always have the drive wheels on the forward side of the roll. If not, the vehicle may be unstable.

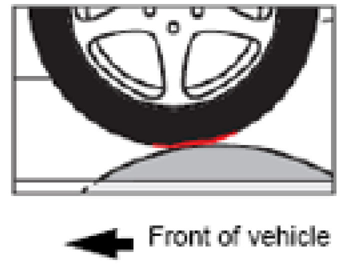


Figure 6-3 Wheel position

On all wheel drive (AWD) dynos, it is best if all four wheels are slightly forward of center. If this is not possible, place the front wheels forward of center and the rear wheels as close to forward as possible.

*On AWD dynos with an adjustable wheelbase, the front roll can be preset to the proper length before putting the vehicle on the rolls or after the vehicle is strapped down. **Do not** attempt to move the front roll with a vehicle installed and the roll lock on and/or the vehicle brake engaged.*

On AD-11 systems drive the wheels into the cradle and centered laterally (Figure 6-4). Once the rolls are unlocked the wheels will settle down into the cradle.

The AD-11 cradle roll is designed with a knurled roll and a smooth roll. For safety and best testing results, make sure the knurled roll is always behind the vehicle's wheels and the absorber housing is on the right-hand side of the car (passenger side on American-built cars).

Figure 6-4 Tire on AD-11 rolls

3. Set the parking brake and stop the engine.

Always consider safety when securing a vehicle to the dyno. Improper installation of tie-down straps may cause accidents. It is better to have what appears to be too many straps than to have a vehicle launch off the dyno.

4. Install the tie-down straps, first at the front and then at the back to secure the vehicle. Leave about an inch (2-3 cm) of slack in each of the straps at this time. Route the tie-down straps away from any hot or rotating parts.

   Refer to Figure 6-5 and Figure 6-6 for suggested tie down methods. The positioning of the straps ultimately depends on the configuration of the anchor points. Follow these guidelines to determine the best method. The use of wheel chocks without straps is discouraged.

   Two straps should be placed from the rear center of the vehicle (preferably on the axle or differential) straight back or at a slight angle to the rear anchor points (Item 1). These are the power straps that will hold the vehicle in place. For high power vehicles, the more straps the better.

   Two straps are placed on the drive axle end of the vehicle (i.e. rear of a rear wheel drive vehicle, front of a front wheel drive, both ends on AWD dynos) and crossed over to the widest anchor point on the opposite side (Item 2). These straps will prevent the vehicle from wandering off the rollset (very important on front wheel drive vehicles).

   Two final straps are placed at the front end of the vehicle to anchor points directly in front or at a slight angle in front of the vehicle (Item 3). These straps will keep the vehicle from moving backwards off the rolls. On AWD dynos the crossed straps will serve this purpose as well.

   On AWD dynos with an adjustable wheelbase, leave the straps slightly loose while moving the front roll under the vehicle.

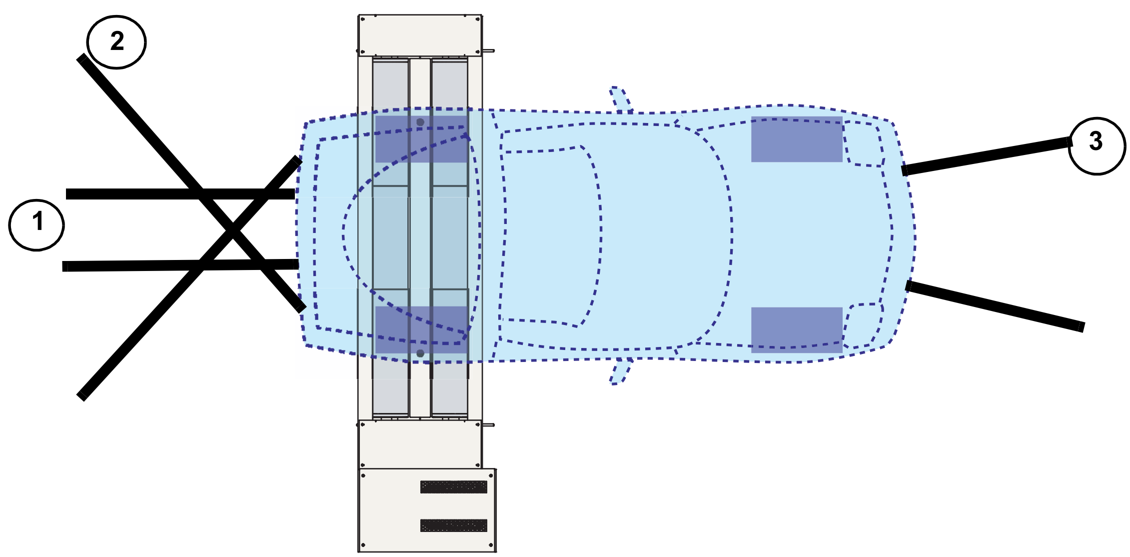


Figure 6-5 AD-11 Rear Wheel Drive

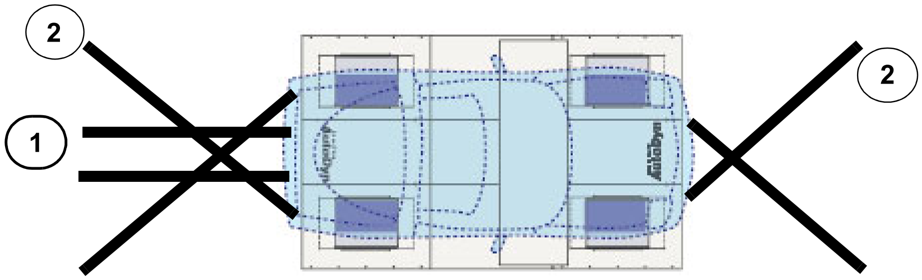


Figure 6-6 All Wheel Drive

5. Get into the vehicle and set the handheld controller on the steering wheel (the rubber bumper on the back will keep it secure). Unlock the parking brake.

6. Unlock the rolls using the “Roll lock OFF” command on the handheld controller.

7. Start the vehicle and let it run slowly in first gear to center the wheels on the rolls.

8. Allow the vehicle to coast to a stop.

9. Tighten the straps to prevent front and back movement of the vehicle on the rolls.

A suggested method for AWD dynos is to secure the rear crossed straps tightly and the front crossed straps a little loose. Run the vehicle slowly and adjust the front crossed straps until the vehicle tracks straight. Then add the rear power straps.

10. Install exhaust extraction systems, cooling air blowers, and other supporting equipment as required.

11. Install an engine speed pick-up and all desired sensors such as optical tachometer on the wheel, temperature and pressure sensors. Verify that the cables stay well clear of hot or rotating parts. Sensor cables touching hot or rotating parts may be damaged and could lead to fire or loss of control.

12. Position the air temperature and humidity sensor near the engine air inlet (or ensure it is in the normal location).

13. Warm up the vehicle (if necessary).

6.5 Basic Steps to Running the AutoDyn

When a test is not running on the dynamometer, the eddy current control should be set to 0%. This ensures that no current is applied to the absorbers. Otherwise they can overheat and be damaged. The load control can be reset to 0% by either of the following methods. 1) Press the "Red Hand" button on the handheld before leaving the dyno unattended. 2) Go to the manual control mode on the handheld and set the load control to 0%. Turning off the 240Vac power to the Eddy Current absorber will remove any chance of current flow but this method should only be used when the dyno will sit idle for long periods.

WinDyn preferences can be set up to quickly prepare the system for testing. A Test Group can ensure the proper configuration files are loaded into the system. WinDyn can receive data from the data acquisition system and save it into a data file with a filename and location determined prior to running the test. Notes can also be entered and saved with the data, Specifications can be set, and other preferences selected using one WinDyn dialog screen.

Preparing WinDyn to accept data and store it in a specific location with a filename will help identify the stored data files. Test Description Notes will help in recognizing the customer, vehicle, and purpose for the test. The test itself is run from the handheld. Post-test analysis is performed with the WinDyn Stored Data Viewer. The Quick Start (Section 6.7.1) provides a reference to the test operation. Copy this page and place it near the computer for easy viewing.

1. Select and load the desired test group file (*.tgp) via the Install Test Group icon on the WinDyn tool bar or by pressing the F2 function key on the computer keyboard. This step is unnecessary if the Test Group is automatically installed when WinDyn is started.

This procedure assumes the correct configuration files are included in the test group design. It is very important that the calibration and control files are installed. Otherwise, you will have to re-calibrate the dyno, or manually load the saved files from the System|Install| menu option. Refer to the Test Group section in the WinDyn Users Guide for more information.* ***A Test Group that loads a CFA without following it with a Calibration file (CAL) will always return the dyno's calibration to a default (uncalibrated) state.***

2. Check screen number 2 (press #2 on the computer keyboard) for the correct barometer, Air Temp, and Humidity readings. Check the Trq1 channel to see if it indicates **0.0, +/- 3.0 lb/ft** with no vehicle on the rolls. If any of these are incorrect, the dyno is not calibrated. A calibration must be performed (see Chapter 10) or a calibration file installed that contains the correct calibration coefficients (See Appendix A in the WinDyn Users Guide for more information).

3. Press "S" on the computer keyboard to access the WinDyn Test Setup screen (See Figure 6-7). This dialog will set all the preferences for WinDyn to ensure proper test results.

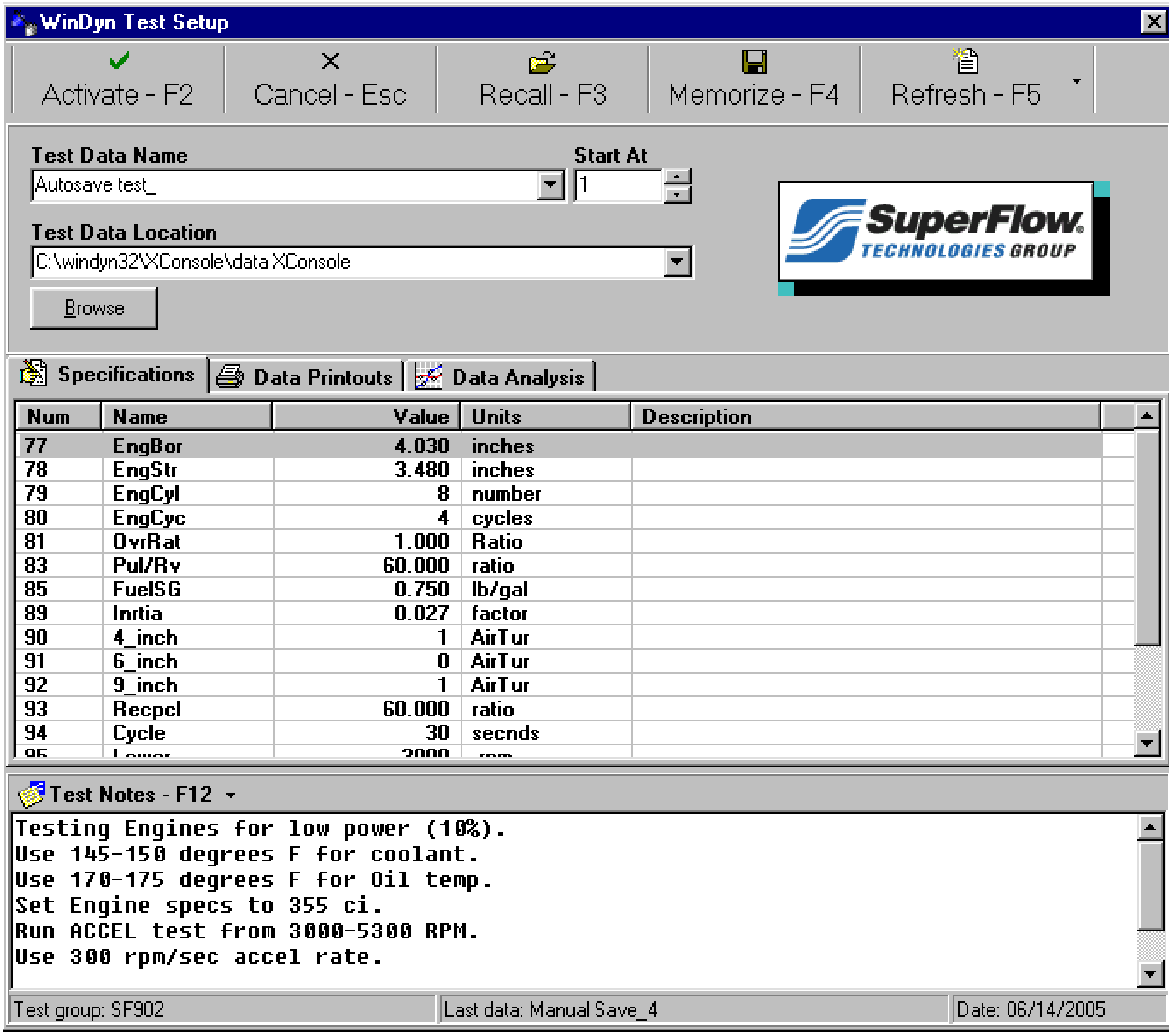


Figure 6-7 WinDyn Test Setup

4. Set up the Filename sequence for this series of tests by entering the desired filename in the "Test Data Name" field. Use a name that identifies the engine. Do not end the name with a number as WinDyn will tag the name with a sequence number. Set the "Start At" number to "1". This is the sequence number and will automatically increment with each saved test.

If the "Start At" number is set to 1 and there are already saved tests in the folder with the same name, WinDyn will automatically search for the next available number and tag it to the filename. WinDyn will never inadvertently overwrite an existing file.

5. Set up the correct folder to store the data files by entering a filepath in the "Test Data Location" field. Use a folder name that identifies the engine owner or the customer. A drop down menu will show the previous ten folders used. A browse button is provided to search for a folder. The folder location can be anywhere on the computer but it is best to keep them together with other WinDyn files.

6. Check for the correct vehicle and test specifications. If the specifications are wrong, enter the correct specifications by selecting the channel and press enter (or click on the channel name). Specifications can also be saved and installed with a saved Specification file.

See Chapter 3, section 3.2 in the WinDyn Users Guide for more information on Specifications. Chapter 9 in this manual gives specific details on each specification channel and how it is used by the system.

7. Enter Test Notes. These notes can include such things as details on the test engine, contact information about the owner, reasons for testing the engine, results of the test, etc. The entered information will be saved with the stored "test data" files (*.SFD). Once the data is stored, additional information may be later added to the file via the F10 key using the Stored Data Viewer program. See Chapter 4 the WinDyn Users Guide for more information on test description notes and data analysis.

8. Press F2 or click on "Activate" to install the new test settings.

9. The dyno sensors should be zeroed before the car is rolled onto it. Once on the dyno, the load cells will read a torque while the roll brake and/or vehicle brakes are applied. Once these brakes are released, the torque readings should go back to zero as the car will now be restrained by the straps.

If the system is calibrated properly as directed in Chapter 10, a zero reference offset will be included in the calibration file (.CAL). If and when the calibration file is installed when a Test Group (*.TGP) is opened, all sensors will automatically be zeroed. However, in situations of extreme atmospheric pressure changes, the zero reference may be off. For more information on Calibration files, see Appendix A in the WinDyn Users Guide.*

To zero the sensors, press **Autozero** on the handheld (the "F" key). Then press **All Channels** (the "B" key). This zero reference will be good for hours.

10. Load the vehicle on to the dyno; see section 6.4 for instructions. If using nylon straps, insure none of them are near any hot surfaces or they might melt. Also, make sure they are not near any rotating parts.

11. Select a method for obtaining engine speed. See Section 6.8 for information and Section 6.9.4 for the procedure.

12. Connect any additional sensors to the vehicle. Place the Temp/Humidity probe in the air stream of the air intake or in its normal location (to get repeatable results the probe should be in the same location for every test).

13. Select and Start the desired test via the handheld “Test” menu (Figure 6-8). Follow the prompts to run the test. Data from the test will automatically be stored to the computer at the end of the test. Repeat the test if desired.

Push “Test” (the G button)
Push “Select Test” (the A button)
Push the number button corre-sponding to the test.
Push “Start Test” (the B button)

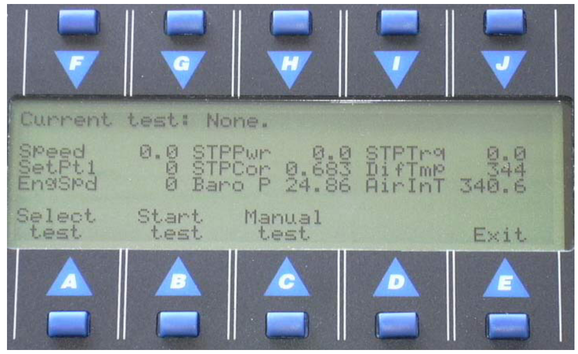


Figure 6-8 Handheld Test menu

The test will prompt for the use of ProFilter. If used, there must be a good engine speed signal for it to work properly. If ProFilter is used, the test will automatically set the correct parameters based upon the chosen engine speed signal source. If a perfect engine speed signal is not possible, ProFilter should not be used.

ProFilter is a special WinDyn feature that will take high speed recorded data and post-process it to provide smoother data with even increments of engine RPM on the data printout. See Chapter 3 in the WinDyn Users Guide for more information on ProFilter and how to use it.

14. Upon completion of the test, let the vehicle coast down to a stop and let it cool down as necessary before shutting off the engine. The Eddy Current absorber will automatically assist in stopping the vehicle. Wait for the roll to stop before getting out of the vehicle.

15. Press “Shift F3” on the computer keyboard to open the saved data file dialog. Select the desired file. Use the WinDyn Stored Data Viewer to analyze, print, and plot the data. See Chapter 4 in the WinDyn Users Guide for more information on the Stored Data Viewer.

16. Remove the vehicle from the dynamometer. See section 6.7 for details.

6.6 Analyzing the test results

All automated tests provided by SuperFlow will save the test data automatically on the computer. The recorded data can be viewed, plotted, and printed using the WinDyn **Stored Data Viewer**.

A utility program (**SuperFlow Explorer**) is available on the WinDyn Tools menu to assist in locating data files (see Chapter 3, section 3.4 in the WinDyn Users Guide for details).

Click **Analyze|Saved Test|View** on the Windyn main menu to start the Stored Data Analysis program of WinDyn and display the results of the test in tabular format. Use the numeric keys or the mouse to select any of ten available pages.

Click on the Plot Test button (icon) or click **View|Plot** to display the results in graphical format. Use the numeric keys or the mouse to select any of ten available pages.

Click on the Print Test button (printer icon) to print the tabular data or select **File|Print Plot** to print the graph.

Refer to the WinDyn Help screens or the Chapter 4 of the WinDyn Users Guide for information on how to use the data analysis features of WinDyn.

6.7 Removing the vehicle

WARNING: *Some vehicle parts may still be hot and could cause burns. Be careful when removing cables, sensors, and tie-down straps.*

1. Lock the rolls using the “Roll lock ON” command (“C”-key) on the handheld controller.
2. Make sure the parking brake is set.
3. Disconnect all sensors and cables
4. Remove exhaust ducts and other supporting equipment
5. Remove the tie-down straps
6. Get in the vehicle and gently release the parking brake to let the vehicle roll off the rolls or settle into the cradle.
7. Drive the vehicle off the dynamometer.

6.7.1 Quick Start

Start with the computer to prepare WinDyn.

	Computer Keyboard	Action Description
1)	F2	Open desired Test Group
2)	2	Check for torque zero and weather conditions
3)	S	Enter data file name and set “Start At” to the desired number
4)		Set System File Path (folder) where data will be stored
5)		Check Vehicle Specifications. Modify if necessary
6)		Enter Test Description notes specific to the test

Prepare the vehicle for testing

7) Zero all sensors by pressing Autozero on the Handheld and then pressing All Channels.

8) Load the vehicle on to the dyno; see section 6.4 for instructions.

9) Select a method for obtaining engine speed. See Section 6.8 for instructions.

10) Connect any additional sensors to the vehicle.

Use the Handheld to run the test.

11)	Test	Displays the Test screen
	Select Test	Select the desired Test Profile number, press Enter ↵
	Start Test	Follow the on screen instructions to perform the test

12) Run the test as directed on the handheld display.

13) Allow the engine to cool before turning it off and stop the rolls before getting out of the vehicle.

14) Return to the Computer to analyze the data.

Press “Shift F3” on the computer keyboard to open the saved test file dialog.

Select the desired file.

Use the WinDyn Stored Data Viewer to analyze, print, and plot the data.

15) Remove the vehicle from the dyno. See section 6.7 for details.

6.8 All Wheel Drive Considerations

Running a vehicle on an All Wheel Drive chassis dynamometer presents some very particular circumstances. The standard situation is a Four or All Wheel drive vehicle is tested on the dyno in all wheel drive mode. In this case, the rear wheel power is measured by the rear roll and the front wheel power is measured by the front roll. Then the two are added together to provide total power.

However, when a two wheel drive vehicle is tested, the non-driven axle and dyno roll is presented as inertia (drag) to the torque load cell on the driven roll. This drag, along with the inertia of the eddy current absorbers, is measured by the load cell on the driven roll and calculated as part of the absorber power of that roll. The load cell on the non-driven roll continues to measure torque but it is a negative value since it is drag. Ideally this negative value is cancelled out by the positive inertia and dyno loss power calculations on the roll. But this rarely happens.

What results is a negative power calculation from the non-driven roll added to the positive power calculation from the driven roll and a lower total power readout than what is really there.

This problem is averted by the use of software switches to “turn off” the non-driven power calculation. These switches are Specification channels that can be set from the WinDyn Specifications editor or from the Specs menu on the handheld. The following are excerpts from the channel descriptions in chapter 9 of this manual.

Channel 88 - FWD **Default Value 1**

Used only on AWD systems

Channel 88 is used to select whether the front rollset power calculations are to be used on the AWD system. A zero in this channel disables the front rollset power calculations in the final wheel power calculation. This channel is not used on the 2WD or AD-11 systems.

Channel 89 - RWD **Default Value 1**

Used only on AWD systems

Channel 89 is used to select whether the rear rollset power calculations are to be used on the AWD system. A zero in this channel disables the rear rollset power calculations in the final wheel power calculation. This channel is not used on the 2WD or AD-11 systems.

Table 6-1 describes the various modes available on the AWD system. It is recommended that this page be copied and placed near the dyno for reference.

Table 6-1 AWD Modes of Operation

Mode	Rolls used and wheel positions	Channel 88 FWD	Channel 89 RWD	Horsepower Calculated by channel 100, WhlPwr
1	Both rolls used, wheels on both rolls. Mode used for AWD vehicles. May also be used for 2WD vehicles.	1	1	Channel 100 calculates total power available to move the vehicle, torque split channel is valid for AWD vehicles. For 2WD vehicles, the torque split will be misleading, as losses from the non-driven wheels will be incorporated into the calculation.
2	Both rolls used, wheels on both rolls. Mode used for front wheel drive vehicles.	1	0	Channel 100 calculates power available at the front wheels only. Although the rear wheels are on the rear roll, any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The front load cell will calculate appropriate losses from the rear rollset.
3	Both rolls used, wheels on both rolls. Mode used for rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. Although the front wheels are on the front roll, any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.
4	Front roll used, rear wheels off rear roll. Mode is used for front wheel drive vehicles.	1	0	Channel 100 calculates power available at the front wheels only. The rear wheels are off the rear roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The front load cell will calculate appropriate losses from the rear rollset.
5	Rear roll used, front wheels off front roll. Mode is used for rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. The front wheels are off the front roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.
6	Rear roll used, front wheels off front roll. Front rollset driveshaft disconnected. Mode is used for extra long rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. The front wheels are off the front roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.

6.9 Obtaining Engine Speed on a Chassis Dyno

One of the more challenging aspects of running vehicles on a chassis dyno is obtaining noise free engine speed readings (RPM). This document provides tips on how to accomplish that goal successfully. First off, here are some of the problems associated with obtaining a good, clean RPM signal:

- Noisy ignition components: wires, plugs, ignition modules
- Noisy electrical components on or near the test vehicle: alternators, generators, welding equipment, electric motors for compressors, high voltage equipment, etc.
- No plug wires (coil over cap systems, diesels, etc.)
- Plug wires inaccessible

All of the above issues contribute to erratic or no RPM readings. There are more, but the basic point is, it isn't an easy job! The first thing to understand is that for power calculations on a SuperFlow chassis dyno, engine RPM is unnecessary. So, if you just need to get some quick horsepower numbers, there is no need to worry about obtaining RPM. Here's why:

Engine Dyno equation: Torque x RPM / 5252.113 = Engine Horsepower

In the above equation, engine RPM is a requirement to compute engine horsepower.

Chassis Dyno equation: Inertia Pwr + Dyno Losses + Roll Pwr = Wheel Power

In the chassis dyno equation, the inertia power is derived from the known inertia mass of the roll being accelerated during the test. We measure the rate of acceleration from the roll speed pickup. Dyno losses are computed at the factory and are embedded in the system configuration. Roll power is derived from the strain gage torque multiplied by roll rpm divided by 5252.113. Thus, no part of the wheel power equation requires engine RPM. You can literally dyno all day and never need engine speed! We even provide a default printout page, number 9, that is defined with roll speed on the X-axis for convenient plotting of power when engine speed is erratic or non-existent.

Of course, having engine speed is still important, particularly for graphing power numbers vs. RPM, and for deriving the "WhlTrq" numbers that come from the wheel power number. Thus, we need a good engine RPM reading, even if it isn't necessary for the power calculations.

SuperFlow provides several methods for obtaining engine speed (Channel 125). One or another will work. However, you may need to experiment with each one before you decide which one works best for the test vehicle.

The latest version of WinDyn with its associated configuration files and test profiles are preconfigured for multiple engine speed selection methods. Older versions of WinDyn and associated configuration files are not, and will require modification to several channels. A utility test profile, Eng_Spd.tpf, is provided to assist in selecting and configuring your system for a specific RPM method. ***We strongly encourage you to run this test profile anytime you are setting up engine speed measurements on a test vehicle.***

6.9.1 Ignition Pickups

SuperFlow offers three different types of pickups to obtain engine speed using the vehicle's ignition system:

Inductive pickup with adjustable gain, P/N 1200A-2450

This pickup may be used on a spark plug wire, coil wire, fuel injection wire, or any pulsing electrical signal wire that has a relationship to engine speed.

- The gain is variable from 0-9, zero the least amount of gain and 9 the most gain. Always try your first attempt with the gain set at 5 and then work from there to try to clean up a bad signal. Dropouts require more gain, spikes require less gain. Do not rely on a good signal at idle as the correct gain setting to use for the dyno test. Typically, the gain used for good idle RPM will not work well for the loaded full throttle test. Ignition pulses are usually stronger at idle than under load, thus, a setting that works for idle RPM will result in loss of signal during an actual test (due to insufficient gain).

- This pickup is polarity sensitive, so you may need to turn over the clamp on the signal wire to get it to work properly. Most ignitions with two plugs and one coil fire one plug positive and one plug negative. This means there is no way to tell initially which way the clamp should be oriented for best response.

- The clamp must remain completely closed during a test; else the signal will be lost. Use a rubber band to hold it closed.

- It does not work well on low voltage pulses (under 5 vdc) if used on a primary coil wire.

- The inductive pickup can also pick up unwanted ignition noise from adjacent cylinder spark plugs and their wires. Try to isolate the pickup from adjacent wires if possible.

A second pickup may be attached to the gain unit to enhance signal strength for weak signals or for systems with a wasted spark pulse on the exhaust stroke. We have used this successfully on multiple cylinder engines where a single probe set on the highest gain setting continues to get signal dropouts.

Since the pickup may work on low voltage wires (~8-16vdc), you may be able to obtain a signal using a fuel injection wire or ignition primary wire. Another option is to install a "test loop" by replacing the ignition fuse with a loop of appropriately sized wire and clamping over that loop. You will have to change the pulses per rev if you use this method.

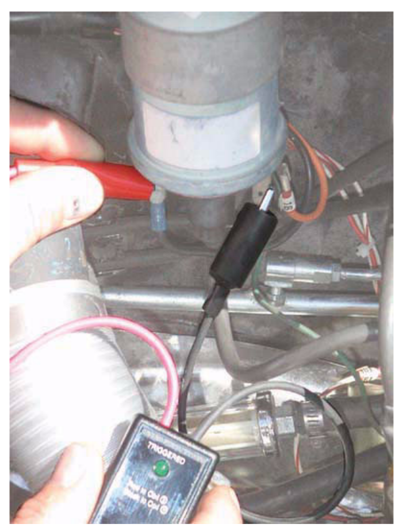
When using this pickup, the pulse per revolution factor is adjusted via the Pul/Rv (old SparkP) channel 83 in the WinDyn specifications. Table 6-2 explains how channel 83 is used with a 4-cycle engine:

Table 6-2 Inductive Pickup Pulse per Revolution

IGNITION PULSES					
	Wasted spark	Wasted Spark	No Wasted Spark	No Wasted Spark	Units
Frequency from the pickup	50	25	25	12.5	Hz
Pulses per Rev	1	1	0.5	0.5	Ratio
Conversion Factor	60	60	60	60	Multiplier
Resultant RPM	3000	1500	3000	1500	RPM

As for connecting this style pickup on late model production vehicles, there simply may not have a spark plug wire to connect to. In that case, improvise by removing the coil-over-cap connection, fabricating a plug wire to extend to the plug and connect the coil-over-cap connection to the other end of the fabricated plug wire extension. Then place the inductive pickup around the extension. We have also used this pickup successfully on injector wires and the primary coil wires, if they are accessible and produce a strong enough signal.

Direct coil pickup, P/N 1200A-1939 (with cable assy. 1200A-2261)



This pickup may be used by connecting its clips directly to the primary wires +/- on an ignition coil. Although the pickup implies correct polarity by the red and black lead colors, it may work better with the leads reversed. Try it. A green LED flashing on the device will confirm a good signal is present.

When using this method, the pulse per revolution factor is adjusted via the Pul/Rv (old SparkP) channel 83 in the WinDyn specifications.

- This device generally works with signal levels of at least 10-12 vdc. Lower levels will not work successfully. Thus, it cannot be used on a 0-5vdc pulse wire.

Many customers report highly successful results with this pickup. Several have grafted different connectors onto it and simply splice into vehicle ignition system wiring harnesses to get a good signal. Obviously, this takes some time and effort, and is usually done on repeat customer vehicles, instead of on the single dyno session user.

Tach wire pickup, P/N 1200A-2188 (with cable assy. 1200A-2448)

This pickup may be directly connected to any pulsing signal source with an amplitude of 5 to 16 volts DC. For instance, if the vehicle has an ignition module with a tachometer output tap, you can connect one lead of this pickup to the signal source and the other lead to chassis ground.

When using this method, the pulse per revolution factor is adjusted via the Pul/Rv (old SparkP) channel 83 in the WinDyn specifications. For Pul/Rv tach output factors, you may need to consult the ignition module manufacturer's documentation. In the event no documentation is available, simply adjust the factor until the WinDyn engine speed display matches the vehicle's tachometer reading (on some ignitions, the tach may need to be disconnected to obtain a signal for WinDyn).

In older systems this pickup attaches to the spark engine speed, channel 11, connector on the interconnect panel. However, the signal is actually routed to frequency channel 9 in WinDyn.

6.9.2 Optical Sensor

IFR Optical Tach, P/N 1200A-0642-1 (with cable assembly 1200A-2448-1)

This pickup was originally designed by Caterpillar Corporation for use in obtaining engine speed on diesel engines, which do not have ignition systems. This pickup can be used to measure the RPM of any rotating object on the test vehicle. It does this by reading its reflected beam from a piece of reflective tape you attach to the rotating object. It works quite well, as long as a rotating object associated with engine speed is available on the engine or drivetrain. This method of obtaining engine speed is often preferred, since it is generally not susceptible to noise interference.

In older systems this pickup attaches to the spark engine speed, channel 11, connector on the interconnect panel. However, the signal is actually routed to frequency channel 9 in WinDyn.

- This cable is for use in the Spark Engine Speed channel 11 connector on the interconnect panel. It uses the same Optical Tachometer sensor that is used for measuring wheel revolutions. It is useful for test scenarios where two optical tach signals are required, one for engine speed, and another one for wheel slip or drivetrain slippage.

- To use this sensor, select channel 86 (OptTac) as a “1”. Set channel 85 and 87 to “0”. It also requires a “ratio” setting in channel 94 (RpmRat).

If using the harmonic balancer on the engine or any other rotating device attached directly to the crankshaft, then the direct readout from the optical tach will be in engine revolutions per second. Thus, simply set channel 94 to 1.000.

However, when using a pulley on the engine that is running at a different ratio than crankshaft speed, you will need to enter that ratio into channel 94. Channel 94 is used with Channel 59 (OptRpm) to convert the optical tach frequency from pulley revolutions per second to engine revolutions per minute.

If you are using the rear wheel assembly on a vehicle, you will need to figure or estimate the correct ratio between the wheel and the engine. Several channels are provided for calculating that ratio: Channels 79, 80, and 81 are specification channels used to calculate an overall ratio in channel 55. If you have entered the correct ratios, then simply enter the OvrRat from channel 55 into specification channel 94, RpmRat. Or, if you know the overall ratio for the gear you are testing in, simply enter it into any one of the drivetrain ratio channels and leave the other two set to 1.000 to obtain the overall ratio. Channel 94 is then used with Channel 59 to convert the optical tach frequency from revolutions per second to revolutions per minute.

If you are attempting to obtain engine speed from the wheel or driveshaft, keep in mind, this method will not work with vehicles equipped with an automatic transmission. Nor can you obtain an accurate RPM reading if you change transmission gears during the test if you are using the wheel or driveshaft for obtaining your optical tach reading.

The ENG_SPD test profile provides an easy and automatic way of calculating the channel 94 value. Run the test and follow the instructions. We suggest that once the correct value is determined, save a Specification file for that vehicle to expedite setup for future tests.

As with the ignition pickups, there are some issues associated with using the optical tach pickups:

- When mounted close (less than 12 inches) to the reflective tape, the signal will sometimes increase (randomly) by a factor of ~10 (2500 now equals 25000). We don't know why, but this has become apparent when using the device for engine speed off pulleys or harmonic balancers on an engine. To alleviate the problem, aim the sensor so it hits the reflective surface at a tangent line instead of directly (90 degrees) at the reflective tape. Or, move the sensor farther away from the reflective surface.

- The above problem may also be related to the vibration issue noted below, where mounting the sensor on a surface off the vehicle or dyno solves the problem. Unfortunately, when using it for engine speed inside the engine compartment, that becomes impossible to do.

- When using the device on the engine pulleys or harmonic balancer, the line of sight to the reflective surface must not become impaired when the engine moves under torque. It may take several positioning alignments to get the reflective surface to stay in line when the engine is under load vice simply idling.

- Use the GREEN LEMO 1200A-2448-1 cable and the channel 11 port on the interconnect panel, not the YELLOW LEMO, channel 12.

The signal is infrared. The sensor saturates in direct or even indirect sunlight. Shadow tubes don't help. You simply cannot use the device outdoors. The sensor doesn't work well in incandescent lighting, either. The same frequency that saturates it in sunlight is also present with incandescent lighting.

Any loss of signal results in erratic behavior. We have found that the system needs several revolutions of the reflective surface before the signal will stabilize. On slow rotating assemblies, multiple reflective points can help resolve this issue. When using multiple points, they must be equally spaced. And the system must know about the multiple points in the channel definition to properly calculate RPM.

- If possible, use a 1 inch by 1 inch square of the reflective tape to insure no loss of signal. Observe vehicle movement during the test to see if that is what may be causing loss of signal (the aiming point is changing).
- Aluminized tape won't work.
- Vibration affects the unit. Sometimes you cannot achieve a good signal when it is sitting on the dyno chassis or eddy current unit. Move it off the dyno onto a stool, jack stand, or whatever and you may achieve a stable signal. Bear in mind, that if the vehicle wheel is severely out of balance, that may be causing you signal loss troubles.

The unit is affected by RFI and just plain noise. We've also had it go crazy when rev limiters are hit. We suspect it acts as an antenna and couples noise interference into the sensor box electronics. When this happens, try isolating the cable away from the dyno and moving the unit off the dyno.

It will work up to about 4-6 feet away from the reflective surface.

6.9.3 Calculated Method

A final method SuperFlow offers to obtain engine speed relies on no pickups at all. Instead, we derive the engine speed from the dyno roll speed. This is done using the following calculations:

WhRvPm = (Speed/60)*(5280/(TirDia*0.2618))

calculates the wheel revolutions per minute using the roll speed and tire diameter. The constant 0.2618 equals Pi divided by 12 and is used to simplify the equation for WinDyn.

EngSpd =WhRvPm*RpmRat

calculates engine speed in a specific transmission gear ratio as a function of roll speed.

The only requirements for this method to work are to know the vehicle's overall ratio for the transmission gear chosen to perform the test and to know the tire diameter. The tire diameter value is entered into channel 84 (TirDia) and the overall ratio is entered into channel 94 (RpmRat).

Although this method may be the least accurate (usually to within +/- 1%), it is a viable method to use when the others either do not work or are not feasible. When using the method with the ProFilter feature, the resultant RPM increments may not be exactly even.

Keep in mind, this method will not work with vehicles equipped with an automatic transmission. Nor can you obtain an accurate engine speed reading if you change transmission gears during the test.

The ENG_SPD test profile provides an easy and automatic way of calculating the channel 94 value. Run the test and follow the instructions. We suggest that once the correct value is determined, save a Specification file for that vehicle to expedite setup for future tests.

6.9.4 Engine Speed Setup

All the previously described methods are preset in the WinDyn default configuration files. They are selectable via the following Specifications Channels:

Channel 85 - IgnPck Default Value 1

Channel 85 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables input signals from channel 11, an inductive spark pickup, coil pick-up or for the direct tach wire connection. A zero (0) in this channel will disable channel 11 inputs to the calculations in channel 125.

Channel 86 - OpTach Default Value 0

Channel 86 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables input signals from channel 9, an optical pickup. A zero (0) in this channel will disable channel 9 inputs to the calculations in channel 125.

Channel 87 - CalTac Default Value 0

Channel 87 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables engine speed calculations with no signal input device, instead using roll speed in MPH, tire diameter, and overall ratio. A zero (0) in this channel will disable these calculations in channel 125.

To use a specific method, simply enable the appropriate method by setting the proper specification channel to a value of "1" and turning off the other methods by setting their specification values to a "0". This can be done via the WinDyn Specifications tool bar icon, by pressing the "S" key on the computer keyboard, or via the handheld Configure|Specs|Edit menu. It can also be done automatically by running the Eng_Spd test profile.

7

Handheld Controller

7. Handheld Controller

7.1. Operator interface controls

"STOP" (K key on front panel)	returns to "start menu", stops running tests, removes load from the absorber, aborts all menu actions without saving.
"RECORD" (L key on front panel)	records one data line for each time it is pressed.
1.2.3. ... "DISPLAY" (M key on front panel)	alternates the current data screens display of units, channel number, measured values.
"PRINT"	Prints a saved test
"TOGGLE" (N key on front panel)	toggles between normal operation and load control command line.
0 → 9 , - , + , .	data entry keys.
"CLEAR"	clears last keystroke entered in an input field.
"ENTER"	confirms data entry in an input field.

7.2. Operator Interface display menus

This section describes the menus displayed by the"Autodyn" system configuration.

7.2.1. System power-up choices

System power-up screen (this screen displays at system power-up and whenever the softkey sequence F-A-D-E is pressed)

```
F          G          H          I          J

SuperFlow NGE system
Sun Jan  1,   0   0:00:00.00am
Setup file: “SF820.set”




Start Set time    System    System
menu   & date     Status    check     Color

A          B          C          D          E
```

Set Time & Date screen

```
F          G          H          I          J

              Time/Date Setup

        TIME:                 DATE:

      0:00:00am          Sun Jan  1,   0
     hours:[ 0]            month:[ 1]
    minutes:[00]             day:[ 1]
    seconds:[ 0]           year:[   0]
                                          Exit

A          B          C          D          E
```

System status screen

Case #1: no nodes connected

```
F          G          H          I          J


System Status:            0:00:00.00am
System type: USAD2EL
Operating system version:   8.34
Program version:   1.36
Nodes connected = 0


B-Proc            CtrlSys               Exit

A          B          C          D          E
```

Case #2: nodes connected

```
 F          G          H          I          J

System  Status:             0:00:00.00am
System  type:  SB1
Operating  system  version:   8.29
Program  version:   3.10
Nodes  connected  =  1

 B-Proc  Nodes    CtrlSys                  Exit
 A          B          C          D          E
```

*Pressing "**Nodes**" will display connected node information*

```
 F          G          H          I          J

System  Status:             0:00:00.00am
Connected  Nodes:  <1>
Connected  to  NameofNode         type-1,1

                                         Exit
 A          B          C          D          E
```

Pressing "CtrlSys" will display the control system modules loaded in your system (not for towing dyno)

```
 F          G          H          I          J
Control  System  settings:

 Dev1 - Stepper motor
 Dev2 - Analog
 Dev3 - None
 Dev4 - Not loaded
                                         Exit
 A          B          C          D          E
```

System check screen

```
F          G          H          I          J

 System  Diagnostics  Results:
RAM  test:  No  Errors,  size  =     1.250Meg
Operating  System  version:   8.34
System  (.prg)  version  =  1.36,  Name:
             <NGE  sensor  system(NewSys.prg)>

 Reset   Node
 System  Names                            Exit

A          B          C          D          E
```

Pressing “Reset System” performs a complete system restart. Make sure the system is in a safe mode prior to performing this restart (no engine, vehicle, or other devices running).

Pressing “Node Names” will display the list of network node names for your system.

Screen color: this function allows the selection of normal or reverse mode for the operator interface

```
F          G          H          I          J

SuperFlow  Test  Console
Sun  Jan   1,    0    0:00:00.00am



 Start  Set&time    System     System
  menu   date       Status      check     Color

A          B          C          D          E
```

```
F          G          H          I          J
SuperFlow  Test  Console
Sun  Jan   1,    0    0:00:00.00am



 Start  Set  time    System     System
 menu    &date       Status     check     Color

A          B          C          D          E
```

7.2.2. Configuration of System

From the power-up screen, the system configuration screen can be accessed by pressing “IHGF”. A warning message will be displayed and an access code (password) is required to continue. The access code can be provided by your customer service representative. The system configuration screen will then be displayed.

```
 F          G          H          I          J

System  Configuration                       Save


Configuration  file  found,  saved  on:
Wed,  Aug  5,  1998  version=  2.00


 Setup   Setup     System     Ctrl
 Accel  Torques     Type      Setup       Exit

 A          B          C          D          E
```

First you must select the system type you are using:

```
 F          G          H          I          J

Select  System  type:[2]

0=  Standard  system  +  Grav  Fuel  System
1=  Standard  system,  no  Grav  Fuel
2=  SF-820  Chassis  Dyno
3=  SF-602  Chassis  Dyno
4=  Motorcycle  Dyno  (CycleDyn)
5=  Towing  Dyno  system


 A          B          C          D          E
```

For an AutoDyn configuration, you will be prompted to enter the roll speed channel, differential temperature channel, differential trip temperature, and ratio. If unsure, leave the default values (speed=ch.10,differential temperature=0, differential trip temperature=0).

Differential ratio is specific to the type of Autodyn you use. You then have the option of defaulting all other parameters for your system. This includes:

- acceleration setup
- torque offsets
- controller scales
- control (PID) parameters
- control setup values

More information on these configurations is available in other sections of this manual

Setup Acceleration measurement:

```
 F          G          H          I          J
---------------------------------------------------
Acceleration measurement:
System channel:[10]          |  Set system chan
pulses/rev:    [ 60]         |  to zero to dis-
interval:      [ 20]         |  able. Set Dist
Coefficient:   [7.4969826]   |  Coeff to zero
Memory Chan:   [ 0]          |  to disable the
Dist Chan:     [  5]         |  distance accum-
Dist Coeff:    [28811.592]   |  ulation.
---------------------------------------------------
 A          B          C          D          E
```

Setup Torque measurement. This does not apply to SF-2242 boardsets. For 1942/2060 boardsets, torque offsets are normally 10%

Pressing "Ctrl Setup" allows selection of scaling factors for the 2 controllers. Both are normally scaled at 100%.

Upon completion of all configuration settings, the system will prompt for a restart. Make sure that no engine, vehicle, or other device is controlled by the system before restarting.

7.2.3. Start menu choices

Start Menu screen (this screen will also display whenever the red stop key is pressed)

```
 F          G          H          I          J
---------------------------------------------------
Autozero   Test     Data     Configure    Help

Ch#1        0 Ch#2        0 Ch#3        0
Ch#4        0 Ch#5        0 Ch#6        0
Ch#7        0 Ch#8        0 Ch#9        0


Boost    Blower   RollLock  DiffLock
On[Off]  On[Off]  On[Off]   On[Off]   Starter
---------------------------------------------------
 A          B          C          D          E
```

7.2.3.1. Autozero functions

Autozero screen

```
 F          G          H          I          J

Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0

Autozero:  All         Single
        channels     channel                Exit

 A          B          C          D          E
```

Autozero all channels (timed message)

```
 F          G          H          I          J
Autozero   Test         Data   Configure   Help

Zeroing  all  sensor  channels

Boost     Blower   RollLock  DiffLock
On[Off]  On[Off]   On[Off]   On[Off]   Starter
 A          B          C          D          E
```

Autozero single channel screen (note: it is not required to use the “Select” command; by pressing the channel # key the channel will be selected)

```
 F          G          H          I          J
Select  channel  to  zero..
<Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
<Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
<Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
<Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
<Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx

PageUp   PageDn    Select   SortList   Exit
 A          B          C          D          E
```

Autozero single channel selection screen

```
 F          G          H          I          J
Select  channel  to  zero..
<Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
<Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
<Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
<Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
<Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx


Enter  Channel  Number  :  [  0]
 A          B          C          D          E
```

Autozero single channel (timed message)

```
 F          G          H          I          J


Autozeroing  channel  xx  [ChName]




Autozero:  All          Single
        channels      channel                 Exit
 A          B          C          D          E
```

7.2.3.2 Test functions

Test screen

```
 F          G          H          I          J
Current  test:  None.

Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0


Select    Start      Manual
test      test       test                     Exit
 A          B          C          D          E
```

Select test screen (no computer nodes connected)

```
 F          G          H          I          J

Current test: None.

************ WARNING! ****************
No computer nodes connected...
cannot perform the requested function


Select   Start    Manual
test     test     test                    Exit

 A          B          C          D          E
```

Select test file screen (computer nodes connected)

Case #1: no files found in specified WinDyn path

```
 F          G          H          I          J

***No Files Found***
Press any key...

 A          B          C          D          E
```

Case #2: files found in specified Windyn path (note: it is not required to use the “Select” command; by pressing the test # key the test file will be selected)

```
 F          G          H          I          J

File Selection...            <xxx files found>
 1=<TSTNAME1>   6=<TSTNAME6>
 2=<TSTNAME2>
 3=<TSTNAME3>
 4=<TSTNAME4>
 5=<TSTNAME5>


PageUp  PageDn   Select                   Exit

 A          B          C          D          E
```

Select Test file number screen

```
 F          G          H          I          J
File  Selection...               <xxx files found>
 1=<TSTNAME1>   6=<TSTNAME6>
 2=<TSTNAME2>
 3=<TSTNAME3>
 4=<TSTNAME4>
 5=<TSTNAME5>


Enter File Number :   [  0]
 A          B          C          D          E
```

Test Start screen (no test loaded in system)

```
 F          G          H          I          J
Current test: None.

************ Warning! ****************
No Valid Test profile found
Cannot perform requested function


Select   Start    Manual
 test     test     test                    Exit
 A          B          C          D          E
```

Test Start screen (test loaded in system)

```
 F          G          H          I          J
Current test: TESTNAME

Ch#1          0  Ch#2          0  Ch#3          0
Ch#4          0  Ch#5          0  Ch#6          0
Ch#7          0  Ch#8          0  Ch#9          0


Select   Start    Manual
 test     test     test                    Exit
 A          B          C          D          E
```

Test control screen (note: data displays may be overwritten by test messages and softkeys are labeled by the test)

NOTE if an asterisk (*) appears after the test file name, it indicates that the test loaded is a Hill Simulation Test

```
 F            G             H             I             J

 Stop     Pause   Continue
 [TESTNAME]  is  running  at  step  xxx
Ch#1          0  Ch#2          0  Ch#3          0
Ch#4          0  Ch#5          0  Ch#6          0
Ch#7          0  Ch#8          0  Ch#9          0

 A            B             C             D             E
```

```
 F            G             H             I             J

Stop     Pause    Continue
 [TESTNAME]  is  running  at  step  xx

Increase  to  full  throttle.

 A            B             C             D             E
```

Manual Test screen (note: pressing either “A” or “B” softkey will scroll control modes; press “Done” to activate mode, “Exit” to cancel and return to previous screen)

```
 F            G             H             I             J

 Select  Control  Modes                          Done
----Load---


Speed
Load%
RolTrq

 Select: load%                                   Exit

 A            B             C             D             E
```

Manual test control screen (pressing “Exit” returns the controllers to zero state (no load / no throttle), removes the command line and returns to the Test Start screen)

```
F          G          H          I          J

                                          Modes


Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0

-  Load  controlling  to:  Manual  -
0.00    -5.00     +5.00     Medium     Exit

A          B          C          D          E
```

7.2.4. Stored Data display choices

Data screen ("J" or a direct keypad number entry will scroll through screen 1-9, "Records" displays total lines of data in test, "Number" displays current line #)

```
F          G          H          I          J

First    Last        Up        Down      Screen#

Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0


Save     Erase     Records    Number
Data     data         0          0         Exit

A          B          C          D          E
```

Save Data screen (timed message) (note: this command will cause a WinDyn Database window to display on your PC)

```
F          G          H          I          J

First    Last        Up        Down      Screen#


Save  data  command  sent  to  all
computer  nodes..


Save     Erase     Records    Number
Data     data         0          0         Exit

A          B          C          D          E
```

Erase Data screen

```
 F          G          H          I          J

 Ch#1        0  Ch#2        0  Ch#3        0
 Ch#4        0  Ch#5        0  Ch#6        0
 Ch#7        0  Ch#8        0  Ch#9        0

 Erase  Data…
 Are  you  sure?        Yes        No
 A          B          C          D          E
```

7.2.5. Configuration choices

Configuration screen

```
 F          G          H          I          J
Select  required  function:            Filter:5

Ch#1        0  Ch#2        0  Ch#3        0
Ch#4        0  Ch#5        0  Ch#6        0
Ch#7        0  Ch#8        0  Ch#9        0

 Spec's Calibr.   Control              Exit
 A          B          C          D          E
```

7.2.5.1. Set system filter

In the SF-1942/2060 board-set, it is possible to select “automatic filtering” for individual data channels when building a configuration file. In that case, the filter that will be applied to those data channels will be determined by the “System filter” setting. The table below shows the filter choices, their corresponding corner frequencies, and the recommended applications.

Filter value	Corner frequency	Recommended for:
1	20 Hz	2000 rpm/sec acceleration tests
2	10 Hz	1000 rpm/sec acceleration tests
3	5 Hz	600 rpm/sec acceleration tests step changes during step tests
4	2.5 Hz	300 rpm/sec acceleration tests
5	1.25 Hz	100 rpm/sec acceleration tests (system default setting)
6	0.625 Hz	steady state tests wait time during step tests
7	0.3125 Hz	steady state tests wait time during step tests

When designing automated tests, it is possible to modify the system filter at any time during the test. We recommend to select the suggested filter rate for each type of test or for each section of the test. Press the "J"- key to change the filter.

Following screen allows the selection of the "System filter":

```
F          G          H          I          J

Select  required  function:           Filter:5

Channel1          Channel4            Channel7
Channel2          Channel5            Channel8
Channel3          Channel6            Channel9


Set  automatic  data  filter  to:  [5]

A          B          C          D          E
```

7.2.5.2. Configuration of Specifications

Specifications screen

```
F          G          H          I          J

Current  specifications  file:  SPECNAME

Ch#1          0  Ch#2          0  Ch#3          0
Ch#4          0  Ch#5          0  Ch#6          0
Ch#7          0  Ch#8          0  Ch#9          0


 Select    Save
new  file  file      Edit                  Exit

A          B          C          D          E
```

Select specifications file screen

Case #1: no files found in specified WinDyn path

```
F          G          H          I          J

 ***No  Files  Found***
Press  any  key...

A          B          C          D          E
```

Case #2: files found in specified Windyn path (note: it is not required to use the “Select” command; by pressing the specifications # key the specifications file will be selected)

```
 F          G          H          I          J

File  Selection...           <xxx  files  found>
 1=<SPCNAME1>   6=<SPCNAME6>
 2=<SPCNAME2>
 3=<SPCNAME3>
 4=<SPCNAME4>
 5=<SPCNAME5>


 PageUp PageDn    Select                 Exit

 A          B          C          D          E
```

Select Specifications file number screen

```
 F          G          H          I          J

File  Selection...           <xxx  files  found>
 1=<SPCNAME1>
 2=<SPCNAME2>
 3=<SPCNAME3>
 4=<SPCNAME4>
 5=<SPCNAME5>


Enter  File  Number  :   [  0]

 A          B          C          D          E
```

Edit specifications file screen

```
 F          G          H          I          J

 Select  specification  channel:
 <Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
 <Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
 <Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
 <Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
 <Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx


 PageUp PageDn    Select   SortList    Exit

 A          B          C          D          E
```

Select Specifications channel screen

```
F          G          H          I          J

Select specification channel:
<Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
<Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
<Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
<Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
<Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx


Enter Channel Number : [ 0]

A          B          C          D          E
```

Edit Specifications channel screen (1)

```
F          G          H          I          J

Edit specification channel: ChName

Current value:      xxxx.xx
Enter new value:  [xxxx.xx]





A          B          C          D          E
```

Edit Specifications channel screen (2)

```
F          G          H          I          J

             Specification editor

 Edit specification:
 #Ch, <ChName = xxxx.xx>



 Next     Prev.     Return     Edit
 chan.    chan.     to list    channel     Exit

A          B          C          D          E
```

7.2.5.3. Configuration of Calibration

Calibration function selection screen

```
 F           G           H           I           J

Select  required  calibration  function:

Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0


                    ---  Fuel  System  ---
 Sensors     Slope    Weight     Volume      Exit

 A           B           C           D           E
```

Selection of Sensor calibration ("A" - key)

```
 F           G           H           I           J

Select  required  calibration  function:

Ch#1         0  Ch#2         0  Ch#3         0
Ch#4         0  Ch#5         0  Ch#6         0
Ch#7         0  Ch#8         0  Ch#9         0


 Reload      Save
 file        file      Edit                  Exit

 A           B           C           D           E
```

"Reload file" will load the calibration file last saved on your computer into the test system.

"Save file" will save the current calibration data of your system on the computer.

"Edit" gives access to the individual channels for calibration, as in the next screen.

Sensor Calibration screen

```
 F           G           H           I           J

 Select  channel  to  calibrate
<Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
<Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
<Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
<Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
<Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx


PageUp   PageDn     Select    SortList     Exit

 A           B           C           D           E
```

Select calibration channel screen (note: it is not required to use the “Select” command; by pressing the channel # key the channel will be selected)

```
F          G          H          I          J

 Select  channel  to  calibrate
<Ch#1   >=xx    <Ch#2   >=xx    <Ch#3   >=xx
<Ch#4   >=xx    <Ch#5   >=xx    <Ch#6   >=xx
<Ch#7   >=xx    <Ch#8   >=xx    <Ch#9   >=xx
<Ch#10  >=xx    <Ch#11  >=xx    <Ch#12  >=xx
<Ch#13  >=xx    <Ch#14  >=xx    <Ch#15  >=xx


Enter  Channel  Number  :  [  0]

A          B          C          D          E
```

Calibration method selection screen

```
F          G          H          I          J

              Sensor  Calibration

Calibrating  <ChName>




Calibrate  by:
Default            CurrVal.   Coeff.     Exit

A          B          C          D          E
```

“Calibrate by default” will reset the sensor calibration to the default values specified in the configuration (*.cfa) file.

Calibration screen using Current Value

```
F          G          H          I          J

              Sensor  Calibration

Calibrating  <ChName>

Enter  Current  value   [xxxxx.x]




A          B          C          D          E
```

Calibration confirmation screen using Current Value

```
F          G          H          I          J
             Sensor Calibration

Calibrating <ChName>
Calibrate channel # (ChName)
to xxxxx.x
Is this correct?


 Yes      No
A          B          C          D          E
```

Calibration screen using Coefficient

```
F          G          H          I          J
             Sensor Calibration

Calibrating <ChName>

Enter calibration coefficient
[xxxx.xxx] Unit/Unit



A          B          C          D          E
```

Calibration confirmation screen using Coefficient

```
F          G          H          I          J
             Sensor Calibration

 Calibrating <ChName>
 Set ChName coefficient to xxxx.xxx
 Unit/Unit
 Is this correct?


  Yes      No
A          B          C          D          E
```

Calibrate other channels screen

```
F          G          H          I          J
---------------------------------------------
             Sensor Calibration

Calibrate channel: #xxx <ChName>



 Next     Prev.     Return    Perform
 chan.    chan.    to list    calibr.     Exit
---------------------------------------------
A          B          C          D          E
```

Save calibration screen

```
F          G          H          I          J
---------------------------------------------
Select required calibration function:

Ch#1          0  Ch#2          0  Ch#3          0
Ch#4          0  Ch#5          0  Ch#6          0
Ch#7          0  Ch#8          0  Ch#9          0

Changes have been made,
save in computer file?        Yes        No

---------------------------------------------
A          B          C          D          E
```

Saving calibration message screen

```
F          G          H          I          J
---------------------------------------------
Select required calibration function:


Sending file save request
to computer nodes(s)




                                          Exit
---------------------------------------------
A          B          C          D          E
```

7.2.5.4. Configuration of Limits

***** Note: for future implementation *****

Limits screen

Limits file selection screen

Select Limits file screen

Limits channel selection screen

Select limit channel screen

Limit value edit screen

***** End of Note *****

7.2.5.6. Configuration of the Control System

Control screen

```
F          G          H          I          J

Select Control calibration function:

Ch#1       Ch#2                  Ch#3       0
Ch#4       Ch#5                  Ch#6       0
Ch#7       Ch#8                  Ch#9       0
           Step       Save
PID        Values     settings              Exit

A          B          C          D          E
```

Step Values screen

```
F          G          H          I          J

            Calibrate Step values       Manual

Modes for the "Load " controller:
Select the required control mode
Press "F" to exit...
Press "J" for manual

Mode1       Mode2

A          B          C          D          E
```

Step Values screen for Manual mode

```
 F          G          H          I          J
----------------------------------------------------
          Calibrate Step values           Manual

Calibrating Step values for Manual
COARSE step size : [xxxx.xx]
MEDIUM step size : [xxxx.xx]
    FINE step size : [xxxx.xx]


Calibrate another mode?       Yes        No
----------------------------------------------------
 A          B          C          D          E
```

Step Values screen for Closed Loop mode

```
 F          G          H          I          J
----------------------------------------------------
          Calibrate Step values     Manual
Load    controller
Calibrating Step values for Mode1
COARSE step size : [xxxx.xx]
MEDIUM step size : [xxxx.xx]
    FINE step size : [xxxx.xx]


Calibrate another mode?        Yes       No
----------------------------------------------------
 A          B          C          D          E
```

PID control screen 2 (refer to Section 21 for details)

```
 F          G          H          I          J
----------------------------------------------------
              Edit Control Parameters

Load controller setup
Actuator phase (0=pos) : [0]






----------------------------------------------------
 A          B          C          D          E
```

PID control screen 3

```
 F        G        H        I        J
-------------------------------------------
           Edit  Control  Parameters

Modes  for  the  “Load”  controller:
Select  the  required  control  mode
Press  “F”  to  exit...


Mode1     Mode2
-------------------------------------------
 A        B        C        D        E
```

PID control screen 4

```
 F        G        H        I        J
-------------------------------------------
Parameters  for:  Load  ->  Mode  1
Phase.......   [0]
Open  Rate..  [   0]      Close  Rate..[        0]
P-Gain..[  0.000]         I-Time...    [        0]
I-Gain..[  0.000]         I-Threshold.[     0.00]
D-Gain..[  0.000]         D-Time...    [        0]
Delay.....[    0]         Filter  Rate.......  [0]

Calibrate  another  mode?      YES      NO
-------------------------------------------
 A        B        C        D        E
```

Saving Control Settings message screen

```
 F        G        H        I        J
-------------------------------------------
Select  Control  calibration  function:


Sending  file  save  request
to  computer  nodes(s)


          Step      Save
 PID     Values   settings            Exit
-------------------------------------------
 A        B        C        D        E
```

7.3. Dynamometer Controls

```
 F          G          H          I          J

Autozero   Test      Data      Configure    Help

Ch#1          0  Ch#2          0  Ch#3          0
Ch#4          0  Ch#5          0  Ch#6          0
Ch#7          0  Ch#8          0  Ch#9          0


Boost     Blower    RollLock   DiffLock
On[Off]  On[Off]   On[Off]    On[Off]     Starter

 A          B          C          D          E
```

7.3.2. Blower control

This key turns cooling fans or exhaust extraction fans on and off via a digital output.

7.3.3. Roll lock control

This key turns the roll brakes on or off. A speed interlock prevents the roll brakes from engaging if the rolls are turning. The roll brakes on the AutoDyn are intended to lock the rolls at rest only, not to decelerate them from any speed.

7.3.4. Differential lock control

On some models of the AutoDyn, the differential can be locked with this command.

7.3.5. Starter control

This key can control an external starter circuit.

8

Theory Of Testing

8 Theory Of Testing

8.1 Overview

8.1.1 Inertia Testing

Mechanical power is defined as the ability to accomplish a certain amount of work in a certain amount of time. On an inertia chassis dynamometer, the work is accomplished by accelerating a roll of known mass and inertia. If time and rate of acceleration are recorded, it is possible to derive power. Inertia dynamometers provide a fast, cost effective, and reasonably accurate means to determine the maximum power output of an engine or vehicle.

Important

There is frequent confusion over the terminology and interpretation of the specifications of inertia dynamometers. Inertia is the resistance of a mass to linear or angular acceleration and is normally expressed in lbs.in^2 *[*kg.m^2*] or* lbs.in.sec^2*. “Roll inertia” on SuperFlow dynamometers is provided in “lbs. [kg] of equivalent vehicle weight” which is easier to relate to real-world situations. This number actually means that the roll simulates the inertial resistance to acceleration of a vehicle of this weight. For convenience, the documentation generally uses the term “XXX lbs. roll”. Once again, this should not be interpreted as the actual mass of the roll but as the equivalent vehicle weight. For example: the inertial resistance of the roll to acceleration of a 450 lbs. (205 kg) roll as used in our inertia-only CycleDyn dynamometer models is similar to that of a motorcycle of 450 lbs. (205 kg) total weight (= including the rider).*

Ideally, the inertia (equivalent vehicle weight) of the roll should match the actual weight of the vehicle under test for perfect simulation of on-road performance. Because the weight of the vehicle under test varies considerably, this is only possible with variable inertia dynamometers. Some variable inertia dynamometers use a series of flywheels which can be individually engaged or disengaged to achieve close approximation of equivalent vehicle weight (Mechanical Inertia Simulation or MIS dynamometers). Other dynamometers use electric motors capable of electrically simulating inertia (Electrical Inertia Simulation or EIS dynamometers). These variable inertia dynamometers are considerably more complex and expensive to build and install and are typically only required for accurate emissions drive cycle simulation. SuperFlow has developed and installed several hundred of such MIS and EIS dynamometers for government-mandated emissions test programs throughout the world.

For performance testing and diagnostic purposes, the inertia (equivalent vehicle weight) of the dynamometer must not necessarily simulate vehicle weight accurately. Differences will show up as slower (if the actual vehicle weight is lower than the dyno simulates) or faster (if the vehicle weight is higher than the dyno simulates) rates of acceleration than would occur on the road. The difference in the rate of acceleration between the dynamometer and the road will not have any influence on the actual power measurement as long as the air and fuel flow are not significantly affected. Air and fuel flow will be affected only if the rate of acceleration differs substantially. This is an important consideration when tuning A/F ratios on an Inertia only dyno.

Developing a good inertia chassis dynamometer with a fixed inertia thus requires a carefully determined compromise between the extremes of vehicle weights to be expected on the system.

SuperFlow has selected a roll with an equivalent vehicle weight to produce accurate test results for the widest possible range of vehicles.

It should be noted that the inertia of the rotating parts of the vehicle should also be factored into the inertial power measurements because power produced by the engine will be used to accelerate the engine, transmission, driveline components, and the wheel itself, in addition to the roll. In other words, if the engine's power output is fixed, then the power available to accelerate the rollset is the power remaining after drivetrain parasitic losses and power consumed to accelerate the vehicle's drivetrain, since it, too, has some inertia.

SuperFlow accounts for this inertia with a constant (40 for CycleDyn, 150 for AutoDyn) in the inertia power equation. This constant is only an estimate, since measurement of each vehicle's drivetrain inertia would be quite difficult and cumbersome to perform. However, since the constant remains unchanged from vehicle to vehicle, any error induced, is still repeatable, and allows assessment of lighter drivetrain components and their affect on measured wheelpower. Please note, that when comparing wheelpower to engine power from an engine dyno, without knowing precise drivetrain inertia values for the vehicle, parasitic loss values may be incorrectly assessed. The constants may be changed via the configuration editor if desired.

8.1.2 Controlled Testing

On an inertia-only dynamometer, power measurements are only repeatable, and thus useful, under wide-open throttle (WOT) conditions. This limits applications for this type of dynamometer. Any problems which occur at constant speed, at partial throttle or during throttle transition will be difficult or impossible to detect or troubleshoot. <u>Due to their dynamic nature, inertia dynamometers are not suitable for engine run-in programs or fuel mapping.</u>

An Eddy Current absorber allows for steady speed and part throttle testing. SuperFlow chassis dynamometers with an Eddy Current absorber can perform a variety of automated tests including acceleration, steady state, and cycle simulation. During steady state testing, the inertia of the drivetrain (and our rollset) will be nulled out, since it will not be accelerating. Thus, steady state testing will produce the most accurate results. Steady state testing also provides more stable measurements for run-in programs and fuel mapping.

On SuperFlow chassis dynamometers, the equivalent vehicle weight values of the rollset are added into the power calculations along with the Eddy Current power measurements. With the added capabilities of the Eddy Current absorber, it is possible to add any amount of additional electrical inertia simulation to control the rate of acceleration for any heavier vehicle weight within the design parameters of the system.

8.2 Tire-Roll Interface

One of the main drawbacks to chassis dynamometer testing is the tire-to-roll interface. On an engine dynamometer, the engine output is directly measured at the flywheel. On a chassis dynamometer the driveline, wheel and tire will have an influence on the measurement results.

None of these mechanical components has an efficiency of 100%, so each of them will sap some engine power and convert it to heat. Some of the net power produced by the engine will be lost in the gearbox, some in the clutch, some in the chain, belt, or drive shaft, some in the bearings, and some will be lost in the tire. Most of these mechanical losses are fairly predictable. The tire losses are the biggest variable.

When a tire rolls on a surface, the deformation of the carcass and rubber in and around the contact patch requires some energy which is converted into heat. The source of this energy is the engine power, so some of this power will be lost as heat. It is unfortunately not possible to easily measure this power loss.

Following variables have an impact on the magnitude of this loss:

- Relative radius of the contact surface to the tire radius. On a flat road, the radius of curvature of the road is infinite and the tire deformation is determined by load, tire structure and tire pressure. On a chassis dyno, the smaller the diameter of the dynamometer roll, the greater the deformation and thus losses in the tire. This explains why a large roll is better than a small one and a single roll is better than a cradle roll system (which results in two successive deformations per revolution). SuperFlow's uses a large diameter single roll possible resulting in the lowest tire losses.

- Downforce on the tire. The greater the weight on the tire, the greater the tire deformation and thus the power losses. There is a common misconception that the vehicle should be weighted or pulled down to avoid tire slip on the roll. While it is true that there is a traction limit, beyond which loss of traction may result, our testing shows that this is not a problem on any motorcycle under 200hp wheel horsepower or any automobile under 500hp wheel horsepower. The knurl of the SuperFlow roll has been selected to provide greatest traction with negligible tire wear. Pulling the vehicle down **excessively** with rear tie-down straps will greatly increase the tire losses, increase the risk of tire damage (due to the build-up of heat in the carcass), and reduce the accuracy of the power measurement.

- Tire pressure and temperature. The tire pressure will have an effect on the deformation, and the tire temperature will have an effect on the rate of increase of the heat build-up. For best results, the tire should be inflated to its highest nominal pressure (as for high speed road use) and the tire temperature should be kept constant. The tire pressure will have a more significant effect on the accuracy and repeatability of the power measurement than the tire temperature.

8.3 Accuracy Of The Chassis Dynamometer

The power measurement of the inertia dynamometer is based on the inertia of the roll and the measured acceleration rate. A highly accurate result can only be obtained if the inertia value and the acceleration are measured with high precision. The eddy current dynamometer uses both the inertia power calculation and the eddy current power calculated by roll torque calibration, added together for the total power measurement. Power consumed by the dynamometer itself is also factored in on both types as parasitic losses.

SuperFlow has developed highly accurate electrical measuring technology for its EIS emissions dynamometers used in government-mandated programs. This sophisticated technology allows us to determine the equivalent vehicle inertia values to the nearest pound.

Every SuperFlow chassis dynamometer is calibrated for inertia of the roll, of the Eddy Current absorber, and of the blowers where applicable. These calibrated values are stored in the electronics of each individual system.

The same technology also allows us to measure parasitic losses (bearing losses, windage, aerodynamic losses) of every rotating part down to the nearest 1/100 of one horsepower. Again, each roll, absorber, and blower is calibrated and the values are stored in the electronics. Aerodynamic losses are adjusted as a function of air density for greatest accuracy.

Acceleration is calculated from speed measurements obtained with a tooth gear and magnetic pick-up. The roll speed measurement is referenced, filtered, and processed to result in several acceleration calculations per revolution of the roll. This results in a much higher resolution than any other system on the market.

The sophisticated technology used in the calibration and in the electronic circuits guarantees the most accurate power measurements possible.

8.4 Interpreting Power Measurements

The SuperFlow chassis dynamometer displays several power calculations. The most important are Wheel Power and Corrected Wheel Power. See the “Description of the Configuration File” (Chapter 9.2.3) for details on the actual calculation formulas used in the system.

8.4.1 Wheel Power

Wheel power is the power that the vehicle puts to the ground in the conditions prevailing on the day of the test. All corrected power and wheel torque numbers are derived from this measurement.

Wheel power is the power actually measured at the tire contact patch in the atmospheric conditions of the test. It is the sum of the inertia power measurement plus the power applied by the Eddy Current absorber plus the parasitic power losses of the dynamometer. No corrections are applied.

This number should be the same as the uncorrected wheel power number of comparable dynamometer systems in similar conditions, provided these systems also take the parasitic losses in the dynamometer itself into consideration and are properly calibrated.

8.4.2 Corrected Wheel Power

Corrected wheel power is the measured wheel power corrected to standard atmospheric conditions. This is the power that the vehicle would put to the ground when tested in standard atmospheric conditions. The correction is only valid for full throttle tests.

A variety of power correction factors exist. They are available from the Society of Automotive Engineers (SAE, STP), the European Community (ECE), the German Industry Standards (DIN), the Japanese Industry Standards (JIS), the International Organization for Standardization (ISO), etc. SuperFlow has selected the SAE, STP, standards for the default configuration files supplied with the dynamometers (ECE and DIN in the metric version). Because WinDyn can be completely user configured, The correction type may be changed this to any standard of choice at any time. See the section on “Power Correction Factors” (Section 8.5) for more details.

8.4.3 Ground Torque

Wheel torque is calculated from wheel power and Roll Speed corrected to standard conditions using the power correction factors (SAE for CycleDyn and STP for AutoDyns). The is the torque which the vehicle would deliver to the ground when tested in standard conditions.

8.4.4 Wheel Torque

Wheel torque is calculated from wheel power and engine speed. No corrections are applied. The calculation is relative to the conditions prevailing on the day of the test. Although this is not the actual measured torque applied to the ground, it is a common value used in marketing and advertising to represent torque of the vehicle under test.

8.4.5 Corrected Wheel Torque

Corrected wheel torque is the calculated wheel torque corrected to standard atmospheric conditions using the power correction factors outlined above. This is the torque of the vehicle when tested in standard conditions. Corrected torque is only valid for full throttle tests.

8.5 Power Correction Factors

The power output of an internal combustion engine is significantly influenced by barometric pressure, ambient air temperature, and air humidity.

- Lower ambient barometric pressure reduces the density of the air, thus reduces the amount of oxygen filling the cylinder for each cycle, resulting in lower power output. Conversely, higher barometric pressure increases power.
- Lower ambient air temperature results in increased density of the air, thus increases the amount of oxygen filling the cylinder for each cycle, resulting in higher power output. Conversely, higher air temperature reduces power output.
- Lower air humidity (less water vapor) leaves more room for oxygen per cubic foot of air, thus increases the amount of oxygen filling the cylinder for each cycle, resulting in higher power output. Conversely, higher air humidity reduces power output. Higher humidity may also reduce the burn-rate in the cylinders.

There are power correction standards for gasoline and diesel engines, for applications in road vehicles, stationary engines, or marine engines, etc. For a SuperFlow chassis dynamometer, relevant standards are those generally intended for gasoline engines in road vehicles.

Power correction standards try to estimate what the vehicle power would be under reference conditions. They cannot calculate exactly what that power output would be. The greater the difference between the ambient conditions during the test and the reference conditions, the greater the error in the estimate. Most correction standards include limits on their applicability. This limit is typically +/- 7%. This means if the correction factor is greater than (>) 1.07 or less than (<) 0.93, the corrected power numbers are not considered to be acceptable, and the test should be performed again under conditions which are closer to the reference conditions.

For most applications this is less of a problem, and the corrected power numbers are still the best basis for comparisons. However, keep this into consideration when comparing test results obtained under considerably different test conditions. At a single location, the correction factor will usually vary less than 5% through the year.

Power corrections are only valid for Wide Open Throttle (WOT) tests. **Corrected power numbers for any test performed under partial throttle conditions should be disregarded.**

8.5.1 Standards

Several Standards organizations have determined methods for estimating power under reference conditions. The best-known organizations are:

- SAE (Society of Automotive Engineers), USA
- ECE (European Community), Europe
- DIN (Deutsche Industrie Norm), Germany
- ISO (International Standards Organization), worldwide
- JIS (Japanese Institute for Standardization), Japan

The default configurations supplied with the SuperFlow chassis dynamometer include power corrections to the following standards: SAE, STP, ECE, DIN.

There is a tendency for all these standards to converge. The only worldwide power correction standards at this time are the ones determined by ISO. For internal combustion engines in road vehicles, this is the ISO 1585 standard. The current SAE J 1349 and ECE standards are nearly identical to the ISO 1585 standard.

8.5.1.1 SAE

The SAE standard applied is a modified version of the SAE J1349 standard of June 1990. Power is corrected to reference conditions of 29.23 InHg *[99 kPa]* of dry air and 77° F *[25° C]*. This is the default correction used on CycleDyns.

8.5.1.2 STP

The STP (also called STD) standard is another power correction standard determined by the SAE. This standard has been stable for a long time and is widely used in the performance industry. Power is corrected to reference conditions of 29.92 InHg *[101.3 kPa]* of dry air and 60° F *[15.5° C]*. Because the reference conditions include higher pressure and cooler air than the SAE standard, these corrected power numbers will always be about 4% higher than the SAE power numbers. This is the default correction used on AutoDyns.

8.5.1.3 ECE

The ECE standard is based on the European Directives. Power is corrected to reference conditions of 99 kPa [*29.23 InHg*] and 25° C [*77° F*].

8.5.1.4 DIN

The DIN standard is determined by the German automotive industry. Power is corrected to reference conditions of 101.3 kPa [*29.33 InHg*] of dry air and 20° C [*68° F*]. With the advent of European legislation and standards, national standards such as the DIN (formerly widely used) are now less significant.

8.6 Aerodynamic Power

FAxCd (Frontal Area x Coefficient of Drag, Channel 78), of the standard CycleDyn and AutoDyn configuration files is used in the Road Load automated test to simulate aerodynamic drag at any road speed up to the maximum speed of the vehicle. The charts below are provided to help you determine the proper value to enter in this Specification channel. There is a chart for US units and one for Metric units.

The easiest way to use the chart is to have a maximum corrected wheel power number for your vehicle.

Wheel power can of course be obtained easily by performing a power run on the dynamometer. The maximum speed the vehicle can reach on the road can be estimated or assumed (for unmodified vehicles, the manufacturer’s rated top speed can be used).

On the chart, power is on the Y-axis (left), and speed is on the X-axis (bottom). The graphs themselves represent the power needed to reach a given speed for a given aerodynamic drag (FAxCd).

Trace straight lines for the maximum corrected wheel power and maximum speed of your bike; then find the FAxCd graph closest to where both lines intersect. The value for this FAxCd line can then be used as input for channel 78.

Here is an example:
Assume a Honda CBR1100XX Blackbird has 133 Corrected HP at the rear wheel, and rated at 181 mph. The intersection of the lines indicates a FAxCd about halfway between 2.5 and 3.0, or 2.75. Entering this value provided a good starting point for the Road Load test. Some more fine-tuning of the value resulted in a top speed of 181 mph at a FAxCd of 2.6 on the dyno.

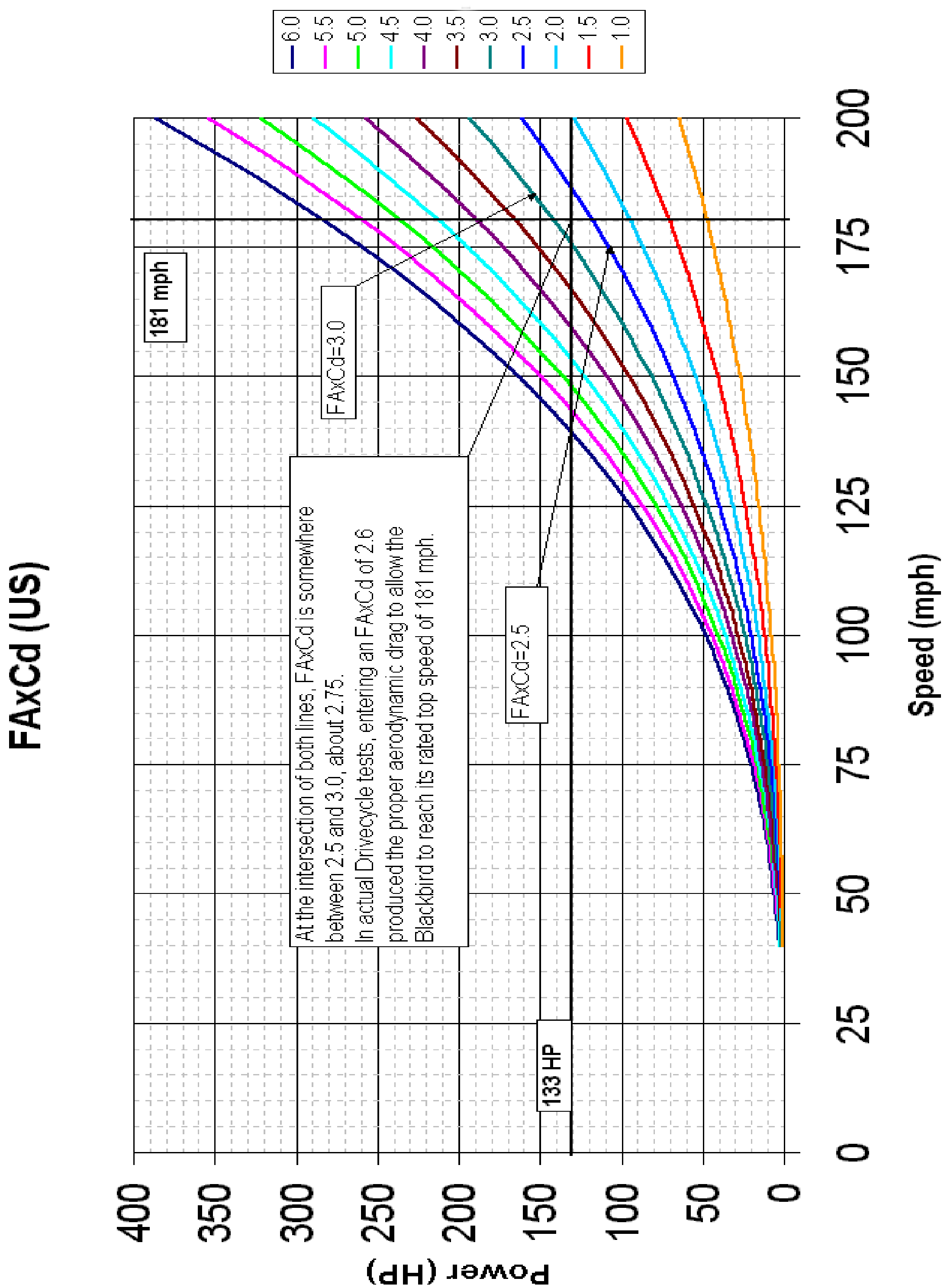


Figure 8-1 Frontal Area Coefficient of Drag, US

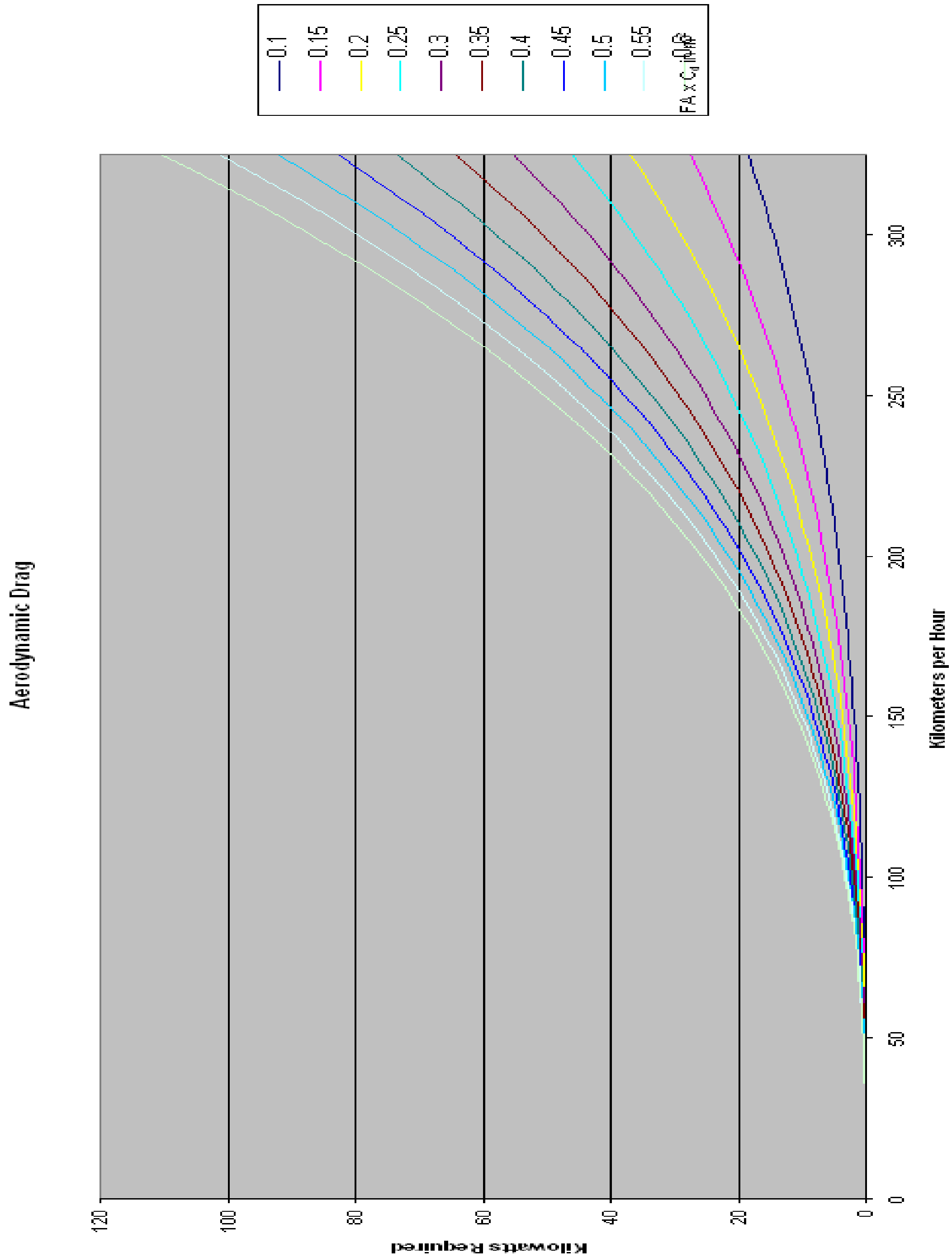


Figure 8-2 Frontal Area Coefficient of Drag, Metric

8.7 Test Profile Descriptions

The following tests are provided as standard tests for our chassis dyno products:

8.7.1 Inertia Tests

These are simple acceleration tests that do not apply load from the eddy current absorber during execution of the test. These tests should be run in a single gear at wide open throttle.

Power is calculated from the rate of acceleration of the dyno system inertia mass and from the dyno system parasitic losses. Power contributed by the load cell is minimal (except on AutoDyn's, where the load cell also measures some parasitic losses), however, it is also added to the inertia power channel to provide the total wheel power value.

All of these tests record data automatically and is saved at the end of each test to an SFD file on the computer disk drive. All tests are generally performed at wide open throttle, but may be performed at any fixed throttle position.

8.7.1.1 ProInrt.tpf

This is the most commonly used test profile for chassis dynos. The Inertia test prompts the operator for an initial test speed in MPH at which the data acquisition system will begin recording data. An ending speed in MPH is then requested and is used by the test profile to terminate recording of data. The test profile also checks for a negative rate of acceleration which will also terminate recording of test data, in the event the test is aborted before the upper test speed is achieved.

At the end of the test, the eddy current absorber is engaged to return the vehicle to the starting MPH speed. Another identical test can then be performed by pressing the “NEW RUN” selection, or the test may be stopped by pressing the “STOP” selection.

When the “STOP” selection is pressed, the eddy current absorber will engage to bring the vehicle speed to 0 MPH. If you do not wish to return the vehicle speed to 0 MPH, simply press the big red hand (reset) function on the handheld to end the test.

8.7.1.2 Mph_Rpm.tpf

This test is identical to the Inertia.tpf except the upper recording termination point is determined by engine speed, RPM, instead of vehicle speed (MPH).

8.7.1.3 Rpm_RpmA.tpf

This test is identical to the Inertia.tpf except the lower start point and upper recording termination point is determined by engine speed, RPM, instead of vehicle speed (MPH).

At the end of the test, the eddy current absorber is engaged to a value of 35% to apply braking force to return the vehicle to the approximate starting MPH speed.

This test may be stored in an “optional tests” folder instead of the normal test folder. If you do not have this test and would like a copy, please contact our Customer Service Department.

8.7.2 Controlled Acceleration Tests

These tests are only available on eddy current equipped dynamometers.

The controlled acceleration test is similar to the inertia test in that the operator accelerates the vehicle from a starting speed to an ending speed. This test should be run in a single gear at wide open throttle.

Power is calculated from the rate of acceleration of the dyno system inertia mass and the power absorbed by the eddy current absorber strain gage during the test. Dyno parasitic values are also added to the wheel power calculation, as in the inertia style tests. The difference from an inertia test is the rate of acceleration is controlled during the entire test by the eddy current absorber.

This test is similar to the type commonly used on SuperFlow engine dynamometers. The engine accelerates at the same rate throughout the test. <u>This test is far more accurate than inertia tests for tuning the engine, especially when observing air/fuel ratio data.</u> Power numbers for this type test may differ slightly from those observed under inertia only conditions. <u>However, these numbers are a more accurate representation of the actual power available to propel the vehicle than those presented by the inertia style test.</u>

The rate of acceleration should be chosen to closely match the vehicle's typical usage rate of acceleration. This is particularly important for calibrating air/fuel ratios. Choosing an acceleration rate that is different than the vehicle's common usage may result in a too rich or too lean air/fuel ratio during normal vehicle operation off the dyno.

These tests record data automatically and is saved at the end of each test run to a SFD file on the computer disk drive. All tests are generally performed at wide open throttle, but may be performed at any fixed throttle position.

8.7.2.1 Proaccel.tpf

The Controlled Acceleration test prompts the operator for an initial test speed in MPH at which the data acquisition system will begin recording data. An ending speed in MPH is then requested and is used by the test profile to terminate recording of data.

A time interval in seconds for the duration of the test is also requested. The time interval for these tests must exceed that which it takes to complete a basic inertia test in the same speed range. Otherwise, the eddy current absorber is turned off during the test, resulting in an inertia style test.

Once all parameters have been entered, the operator is prompted to PROCEED. The operator should select the gear for the test and accelerate the vehicle to the starting MPH. The eddy current absorber will engage and hold the vehicle. The operator should maintain wide open throttle and press the ACCEL selection on the handheld to begin the acceleration test.

The vehicle will accelerate at a constant rate toward the upper test speed. At the end of the test, the eddy current absorber is engaged to return the vehicle to the starting MPH speed. Another identical test can then be performed by pressing the “NEW RUN” selection, or the test may be stopped by pressing the “STOP” selection. When the “STOP” selection is pressed, the eddy current absorber will engage to bring the vehicle speed to 0 MPH. If you do not wish to return the vehicle speed to 0 MPH, simply press the big red hand (reset) function on the handheld to end the test.

8.7.3 Step Tests

Step tests are only available on eddy current equipped dynamometers.

The step test uses the eddy current absorber to hold the vehicle at a constant speed for a desired length of time and then samples one data point. This test should be run in a single gear and may be run at any throttle setting.

Power is calculated from the power absorbed by the eddy current absorber strain gage during the test. Dyno parasitic values are also added to the wheel power calculation, as in the inertia style tests.

This test is similar to the type used on engine dynamometers. The engine is allowed to stabilize at each speed point before collecting data. This test is the most accurate for tuning the engine, especially when observing air/fuel ratio, temperature, and pressure data.

Power numbers for this type test may differ slightly from those observed under inertia or controlled acceleration conditions. However, these numbers are perhaps the most accurate representation of the actual power at a specific engine speed under fully loaded conditions.

These tests record data automatically and is saved at the end of each test run to a SFD file on the computer disk drive. All tests are generally performed at wide open throttle, but may be performed at any fixed throttle position.

8.7.3.1 Steptest.tpf

This Step test prompts the operator for an initial test speed in MPH at which the data acquisition system will begin recording data. An ending speed in MPH is then requested and is used by the test profile to terminate recording of data.

A step increment in MPH is requested next. A time interval in seconds for each step point of the test is then requested. The time interval for these tests is used to hold the vehicle at each MPH step for a length of time prior to sampling data.

Once all parameters have been entered, the operator should select the gear for the test and accelerate the vehicle to the starting MPH. The eddy current absorber will engage and hold the vehicle. The test will begin automatically, holding the vehicle speed constant, sampling a data point, then moving to the next speed setpoint determined by the speed increment size.

At the end of the test, the eddy current absorber is engaged to return the vehicle to the starting MPH speed. Another identical test can then be performed by pressing the “NEW RUN” selection, or the test may be stopped by pressing the “STOP” selection. When the “STOP” selection is pressed, the eddy current absorber will engage to bring the vehicle speed to 0 MPH. If you do not wish to return the vehicle speed to 0 MPH, simply press the big red hand (reset) function on the handheld to end the test.

8.7.4 Road Load Simulation Tests

Road Load Simulation tests are only available on eddy current equipped dynamometers.

SuperFlow eddy current absorber equipped chassis dynamometers can perform a road load simulation test. These tests use an estimated vehicle weight (with operator) and an estimated frontal area in equivalent square feet to simulate load applied to the vehicle as vehicle speed increases.

These tests can be used to perform vehicle diagnostic checks under load conditions similar to those experienced on the road. These tests may be run in any gear and shifting during the test is permitted. Any throttle position may be used during the test. Power is calculated from the rate of acceleration of the dyno system inertia mass and the power absorbed by the eddy current absorber during the test. Data recording is not determined by any preset parameters as in an acceleration or step test. Therefore, analysis of recorded data may be more difficult to perform.

8.7.4.1 RoadLoad.tpf

This test simply records data at a predetermined rate of time (the default is every 0.1 seconds). Once the operator starts the test, recording is enabled and the operator may operate the vehicle in any manner desired. The eddy current absorber applies increasing amounts of load as vehicle speed increases.

The factors influencing the amount of load are total vehicle weight (TotlWt, channel 77) and the frontal area entered for the vehicle (FAxCd, channel 78). The test is terminated when the operator presses “STOP” on the handheld selection. Another identical test can then be performed by pressing the “NEW RUN” selection, or the test may be stopped by pressing the “STOP” selection. When the “STOP” selection is pressed, the eddy current absorber will engage to bring the vehicle speed to 0 MPH. If you do not wish to return the vehicle speed to 0 MPH, simply press the big red hand (reset) function on the handheld to end the test.

Data is automatically recorded and saved at the end of each test run to a SFD file on the computer disk drive.

8.7.5 Other Tests

The WinDyn Test Profile Editor allows modification or creation of any kind of test. Here are several that may provide some utility to the user.

These tests may be stored in an “optional tests” folder instead of the normal test folder. If you do not have these tests and would like a copy, please contact our Customer Service Department.

8.7.5.1 ProAero.tpf

The Inertia Load test is only available on eddy current equipped dynamometers.

This test is identical to the Inertia.tpf except it allows the operator to add a percentage of load via the eddy current absorber. This, in essence, simulates a heavier rollset, thus, slowing the rate of acceleration.

This test prompts the operator for an initial test speed in MPH at which the data acquisition system will begin recording data. An ending speed in MPH is then requested and is used by the test profile to terminate recording of data. A load percent is then requested.

The test profile also checks for a negative rate of acceleration which will also terminate recording of test data, in the event the test is aborted before the upper test speed is achieved.

When the test begins, the eddy current absorber applies the percent of load entered, thus making the rollset feel “heavier” to the vehicle during the acceleration run. At the end of the test, the eddy current absorber is engaged to return the vehicle to the starting MPH speed.

Another identical test can then be performed by pressing the “NEW RUN” selection, or the test may be stopped by pressing the “STOP” selection. When the “STOP” selection is pressed, the eddy current absorber will engage to bring the vehicle speed to 0 MPH. If you do not wish to return the vehicle speed to 0 MPH, simply press the big red hand (reset) function on the handheld to end the test.

Power is calculated from the rate of acceleration of the dyno system inertia mass and from the dyno system parasitic losses. Power contributed by the load cell is also used, since there is a constant load applied throughout the test.

Data is automatically saved at the end of each test iteration to a SFD file on the computer disk drive.

8.7.5.2 TirDia.tpf

The Tire Diameter test can be used to determine the actual tire diameter for channel 84, TirDia, in the vehicle specifications. Set up the optical tachometer to observe wheel revolutions on the rear wheel. Accelerate the vehicle to a desired speed and hold the speed constant. Run the test and it will automatically calculate the correct tire diameter and enter it into channel 84. When the test is complete, manually save the new tire diameter in the vehicle specification file using the handheld or WinDyn option.

8.7.5.3 In_Dec_A.tpf

The Inertia Deceleration test is exactly like the Mph_Rpm inertia test but it offers the operator the option of collecting data during coastdown on subsequent runs after the first acceleration run. The coastdown data collection termination point is determined by MPH.

Data is collected at 100 times per second during this test, to allow greater analysis of coastdown data. Data is automatically saved at the end of each test run to a SFD file on the computer disk drive.

8.7.5.4 Decel_A.tpf

This Deceleration test allows the operator to accelerate to a selected speed in MPH and then disengage the clutch or shift the vehicle into neutral to process vehicle coastdown parasitic loss data. This data is available in channel 127, CsDnLs, loss in horsepower. The value will be a negative value, but represents the amount of parasitic loss power in the drivetrain of the vehicle.

Data is collected at a rate of 10 times per seconds and is automatically saved at the end of each test run to an .sfd file on the computer disk drive.

8.7.5.5 Eng_Spd.tpf

The Engine Speed test provides a convenient method for setting up the engine speed pickup on the vehicle you are testing. It prompts the operator through several optional engine speed methods, and provides input screens for selecting and configuring each RPM method. Although this can be done via the specifications editor function within WinDyn, this test profile may speed up that process and can be done while on or in the vehicle.

At the end of the test, be sure to save the new settings to a specification file for the vehicle under test. Simply load the specifications file the next time that vehicle is tested, foregoing the lengthy RPM setup process.

8.7.5.6 RpmRamp.tpf

This test is only available on eddy current equipped dynamometers.

This test allows the operator to perform a ramp test using engine speed parameters instead of MPH. At the beginning of the test, the system compares roll speed to engine speed and calculates a ratio between the two. Once that ratio is known, the test prompts the user for lower and upper engine speed (RPM) setpoints and requests a ramp time. From that point forward, the test functions just like the controlled acceleration test profile, collecting data every 0.1 seconds. Data is automatically saved after each ramp.

Since the system is actually controlling to a factored MPH based on the ratio calculated at the beginning of the test, the actual RPM setpoints may deviate by a small percentage. However, small setpoint adjustments by the operator should allow for compensation of any error.

This test is useful for fuel injection mapping at steady throttle positions at incremented RPM points.

8.7.5.7 Steadyst.tpf

This test is only available on eddy current equipped dynamometers.

This RPM Steady State test allows the operator to perform a steady state test using engine speed parameters instead of MPH. At the beginning of the test, the system compares roll speed to engine speed and calculates a ratio between the two. Once that ratio is known, the operator is prompted for a steady state RPM to control to and a length of time to do so.

The test proceeds to control the vehicle to the desired engine speed (+/-100 rpm) for the desired time. Since the system is actually controlling to a factored MPH based on the ratio calculated at the beginning of the test, the actual RPM setpoint may deviate by a small percentage. However, small setpoint adjustments by the operator should allow for compensation of any error.

This test is useful for fuel injection mapping at a steady RPM for various throttle position settings. Data is recorded every 0.1 seconds and is saved at the end of each RPM point iteration.

9

Description of the Configuration File

9 Description of the Configuration File

9.1 Overview

The Configuration file is used to define the functions of WinDyn and the NGE Data Acquisition System. The Channel Functions, Control Functions, and the Console Display are all defined in the Configuration File. Once established, the file is stored on the PC hard disk and downloaded to the Data Acquisition System memory as required. This file defines the basic elements of WinDyn and is required for proper operation.

9.2 Channel Definitions

Values in *italic* and / or [between brackets] are for metric configurations. Gaps in the numbering of are channels that are not defined or are used as a calculated channel.

9.2.1 Measured Channels

Sensor channels input measured data and convert it to a reading. In some cases the reading is a direct reflection of the input, such volts in to volts out. In other cases the input is convert to a different value, such as volts in to A/F Ratio out or frequency to RPM. Thermocouple channel values are determined by the type of thermocouple used.

On the following channel definitions, the first line after the channel description is the input minimum and maximum values. The second line are the displayed values.

Channel 1 - AirSen

Channel 1 is used to measure the voltage from the ambient air temperature sensor. The voltage is used by Channel 74 to determine the air temperature. This channel has a coefficient of 1.000, no auto zero, and is filtered at 7. Changing the values for this channel is not recommended. Changing the coefficient will alter the values displayed by channel 74. This channel typically requires no calibration.

0.000 1.000 volts
0.000 1.000 volts

Channel 2 - Trq1 (2WD systems)
RWTrq1 (AWD systems)

Channel 2 is used to measure the torque from the differential and the eddy current power absorber. It senses the voltage from the strain gauge and converts it into torque for calculations and power measurement. The default strain gauge calibration coefficient is approximately 1816.9189 lb-ft *[2463.3786 Nm]* per volt. This coefficient will be changed via calibration. The channel is set up for zeroing by command and is set for an automatic filter (allows changes via test profiles). This channel is given parameters so it may be used as a control channel. Is has values set at -9999 minimum and +9999 maximum.

0.000 4.096 volts
0.000 7442.1 lb-ft *[10090 Nm]*

Channel 3 - FWTrq2 (AWD systems only)

For All Wheel Drive (AWD) systems, this channel is used as a measured sensor input for the front rollset load cell. It is then configured the same as channel 2, RWTrq1. However, during calibration, the calibration value must be input as a NEGATIVE number. For this reason, AWD systems may not be run in reverse direction.

0.000 4.096 volts
0.000 7442.1 lb-ft *[10090 Nm]*

Channel 4 - LambVt

Channel 4 is used for auxiliary voltages for expansion. It may be used for 0-5 vdc sensors on -2242 board sensor boxes, or 0-10vdc sensors on 2060-01 board sensor boxes. It is currently defined for use with Lambda sensor inputs. The channel is set for a coefficient of 1.000 and does not require calibration. Filtering is set to 5 and no zeroing (zeroing is not recommended for this channel when using the -2242 board). The maximum voltage on 2242 boards is 4.096 vdc. The channel may be zeroed on 2242 boards if a sensor is connected or if the signal source, pin 5, is grounded.

0.000 4.096 volts
0.000 4.096 volts

Channel 5 - OilTvt

Channel 5 is used for auxiliary voltages for expansion. It may be used for 0-5 vdc sensors on -2242 board sensor boxes, 0-10vdc sensors on 2060-01 board sensor boxes. It is currently defined for use with Oil Dipstick sensor inputs. The channel is set for a coefficient of 1.000 and does not require calibration. Filtering is set to 5 and no zeroing (zeroing is not recommended for this channel when using the -2242 board). The maximum voltage on 2242 boards is 4.096 vdc. The channel may be zeroed on 2242 boards if a sensor is connected or if the signal source, pin 5, is grounded. This channel may be used for other voltage type inputs for systems equipped with a thermocouple module to measure temperatures.

0.000 4.096 volts
0.000 4.096 volts

Channel 6 - HumSen

Channel 6 is the input for the humidity sensor used to measure the humidity of the air. It is used by Channel 120 to calculate relative humidity. This channel has a coefficient of 1.000, no auto zero, and is filtered at 7. Changing the values for this channel is not recommended. Changing the coefficient will alter the values displayed by channel 120, thus requiring no calibration.

0.655 3.195 volts
0.655 3.195 volts

Channel 7 - Freq 1

Channel 7 is used to measure the frequency from auxiliary sensors such as airflow or fuel flow measurement turbines. The coefficient for this channel is 1.000, with a maximum input frequency of 5000 hz. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed.

0.000 5000 hz
0.000 5000 hz

Channel 8 - Freq 2

Channel 8 is used to measure the frequency from auxiliary sensors such as airflow or fuel flow measurement turbines. The coefficient for this channel is 1.000, with a maximum input frequency of 5000 hz. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed.

0.000 5000 hz
0.000 5000 hz

Channel 9 - Tach

Channel 9 is used to measure the frequency from auxiliary sensors such as ignition module tachometer output or optical speed sensor signals. The coefficient for this channel is 1.000, with a maximum input frequency of 5000 hz. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed. In the default configuration the frequency output is combined with Channel 83, Spark Pulses per Revolution, to calculate the engine speed in Channel 125. Channel 9 can alternatively be used for other frequency inputs such as an air turbine if desired (requires changes to the configuration file).

0.000 5000 hz
0.000 5000 hz

Channel 10 - Speed

Channel 10 is used to measure the frequency of the roll from a magnetic pick-up attached to the gear on the differential. This channel is scaled to directly produce a mile per hour reading from the frequency received. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed, and severely alter the calibration of the dynamometer. Changing the values for this channel is not recommended. This channel is also defined as a control channel. It has a minimum value set at 0 and a maximum value set at 200 (150 forAD-11 series).

0.000 44.658 Hz (26.36 Hz for AD-11)
0.000 1.000 mph *[1,609 km/h]*

Channel 11 - EngFrq

Channel 11 is used to measure the frequency from the ignition tachometer pick-up. Either inductive or direct connection pick-ups may be used. The coefficient for this channel is 1.000, with a maximum input frequency of 5000 hz. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed. The frequency output is combined with the Channel 83, Pulses per Revolution, to calculate the engine speed in Channel 125.

0.000 5000.0 Hz
0.000 5000.0 Hz

Channel 12 - OptTac

Channel 12 is used to measure the frequency output from the optical tachometer option. The optical tachometer shines infrared light on to a reflective surface, such as reflective tape placed on the rear wheel of the vehicle, and creates a pulse for each reflection. The coefficient for this channel is 1.000, with a maximum input frequency of 5000 hz. It is set for automatic filtering, to allow changes via a test profile. It is set for no zeroing. Changing the coefficient will alter the values displayed. The optical tachometer is used by Channel 56 and then 57 to determine wheel speed. It is also used with channels 51 and 52 for determination of driveshaft RPM and transmission slip.

000.0 5000.0 Hz
000.0 5000.0 Hz

Channels 13 to 20 - THERMOCOUPLE INPUTS 1 THROUGH 8

Channels 13 through 20 are for standard thermocouple inputs. These may be renamed to fit specific functions by using the Configuration Editor Program. These channels are normally set up for Type K thermocouples. No other type of thermocouple can be used without a hardware modification. The maximum temperature input is 2000^{o}F *[1100 °C]*. These channels require no zeroing and are set with a filter rate of 5.

Channels 21 to 28 - EXHAUST TEMPERATURES 1 THROUGH 8

Channels 21 through 28 are used for measuring exhaust gas temperature thermocouples. They may be used for other temperature measurements if desired. These channels are normally set up for Type K thermocouples. No other type of thermocouple can be used without a hardware modification. The maximum temperature input is 2000°F *[1100 °C]*. These channels require no zeroing and are set with a filter rate of 5.

Channels 29 to 36 - ANALOG VOLTAGES 1-8

Channels 29 through 36 are used for measuring DC voltage inputs. They are currently defined for 0-10 vdc inputs on channels 29-35. Channel 36 is normally defined for 0-20 vdc. Each channel may be configured via hardware modifications for 0-1, 0-5, 0-10, or 0-20 vdc. These channels are set for zeroing by command and are set with a filter rate of 5. The channel is set for a coefficient of 1.000 and does not require calibration.

Channels 29-35:

0.00	10.00 vdc
0.00	10.00 vdc

Channel 36

0.00	20.00 vdc
0.00	20.00 vdc

Channels 37 through 49 - UNUSED

Channels 37 through 49 are not currently used in the standard version of the dynamometer. Eight expansion sensors may be added in this channel slot with optional, additional hardware. The additional inputs could be thermocouples, pressures, or analog voltages. These may be renamed to fit specific functions by using the Configuration Editor Program. They may also be used for additional calculated channel definitions.

Channel 61 - Oil P

Channel 61 is for measuring oil pressure. The transducer has a range of 0-300 psi *[2000kPa]*. It may be recalibrated if required, through the calibration menu, or through changes in the Configuration File. Filtering is set to 5 and zeroing is by command.

0.000	3.636 volts
0.000	150 psi *[1034 kPa]*

Channel 63 - Man. P

Channel 63 is used to measure the manifold inlet pressure or vacuum in inches of mercury. It has a range of -30 to +173 inches of mercury *[-103 to +586 kPa]*. Filtering is set to 5 and zeroing is by command.

0.000	3.636 volts
0.000	407 in.Hg *[1379 kPa]*

Channels 62, 64, 65, 67, 68 AxPrs1 - AxPrs5

These channels are expansion channels for pressure measurement. They may be implemented by buying additional pressure transducers. Filtering is set to 5 and zeroing is by command.

62	0.000	3.636 volts
	0.000	100.00 psi *[689.5 kPa]*
64, 67 & 68	0.000	3.636 volts
	0.000	150.00 psi *[1034.25 kPa]*
65	0.000	3.636 volts
	0.000	200.00 psi *[1379 kPa]*

Channel 66 - Fuel P

Channel 66 is used to measure fuel pressure. It has a range of 0-300 psi *[2068kPa]*. Filtering is set to 5 and zeroing is by command.

0.000 3.636 volts
0.000 300.00 psi *[2068 kPa]*

Channels 69, 70 - Air1 P, Air2 P

Channels 69 and 70 measure air inlet or exhaust pressure. Filtering is set to 5 and zeroing is by command.

0.000 3.636 volts
0.000 276.00 InH2O *[70 kPa]*

Channel 71 - DifSen

Channel 71 is used to measure the voltage from the differential temperature sensor. It is used in channel 75 to provide a temperature reading in degrees F. Filtering is set to 7 and no zeroing is required. Coefficients should not be altered.

0.000 4.096 volts
0.000 4.096 volts

Channel 72 and 73 - CtrlV2, and CtrlV3

Channel 72 and 73 display control voltages 2 and 3 from the WinDyn sensor system. These are used primarily for diagnostics to track the behavior of the control system or other parameters that may be mapped to these channels. They are not normally used for any test applications. Filtering is set to automatic and no zeroing is required. Coefficients are set to 1.000 and should not be altered.

0.000 10.000 volts
0.000 10.000 volts

Channel 76 - BaroP

Channel 76 is used to measure the barometric pressure. The barometric pressure transducer is located on the circuit board installed in the sensor box. If you have an accurate mercury barometer, it is recommended that you calibrate your barometric pressure sensor to exactly agree with the mercury barometer. If you do not have an accurate barometric pressure measurement device, you should use the default calibration or obtain an absolute barometric pressure (station pressure) reading locally. Filtering is set to 7 and no zeroing is required. Coefficients should not be altered.

0.000 3.636 volts
0.000 29.920 inhg *[101.3 kPa]*

9.2.2 Specification Channels

Channels 77 through 99 are all **Specifications** or Constants. The values shown here are defaults. Many will change for each variety of test vehicle. Once a set of **Specifications** has been determined for a particular test vehicle, it is recommended that the data be saved under the name of the vehicle. Before beginning the next test of that vehicle, load in the previously recorded set of **Specifications**, and the whole test system will be automatically configured for the vehicle under test. These **Specifications** are not normally needed to be changed manually if they have been entered correctly the first time and stored under the name of the vehicle.

Channel 77 - TotlWt **Default Value 4000.00 *[1409]***

Channel 77 is for entering the total weight in pounds *[kg]* of the test vehicle with driver. Channel 77 is used by Channel 106 to determine the actual power required to simulate road load power. This channel only applies to the ROADLOAD and PROAERO test profiles. Those profiles will prompt the user for appropriate input when setting up the test parameters.

Channel 78 - FAxCd **Default Value 10.000 *[0.929]***

Channel 78 is used to enter the estimated effective frontal area of the test vehicle in square feet *[m^2]* times the drag coefficient, and used by Channel 107 to calculate the estimated air drag power of the vehicle at each speed. Typical values for vehicles vary from 10.0 to 30.0 ft^2 *[0,93 to 2,79 m^2]*. This channel only applies to the ROADLOAD and PROAERO test profiles. Those profiles will prompt the user for appropriate input when setting up the test parameters.

Channel 79 - EngRat **Default Value 1.000**

Channel 79 is used to enter the ratio between the engine crankshaft speed and the transmission speed. Typically, this value should be 1.00, but unique vehicles may require values between 1.5 and 3.0. Channel 79 is used with Channel 80 and 81 to calculate the overall gear ratio in Channel 55. Channel 79 is not required for any power measurements. It is only used when calculating transmission slip.

Channel 80 - TrnRat **Default Value 1.000**

Channel 80 is used to enter the ratio of the transmission gear used during the test. Channel 80 is used with Channel 79 and 81 to calculate the overall gear ratio in Channel 55. Channel 80 is not required for any power measurements. It is only used when calculating transmission slip.

Channel 81 - DrvRat **Default Value 1.000**

Channel 81 is used to input the drive ratio between the transmission output and the rear wheel. Typical values are between 2 and 4. Channel 80 is used with Channel 79 and 81 to calculate the overall gear ratio in Channel 55. Channel 81 is not required for any power measurements. It is only used when calculating transmission slip.

Channel 82 - DJCorF **Default Value 1.100**

Channel 82 is used as an additional multiplier for creating **SAEPwr** comparisons to uncalibrated dynamometers in your marketing area. The factor is used in channel 114 to add 10% more power to Channel 112. **Numbers created using this factor are for speculation only, and should not be used as a standard of any kind.**

Channel 83 - Pul/Rv **Default Value 0.500**

Channel 83 is typically used to enter the number of spark pulses per revolution for the engine RPM measurement. If the engine speed appears to be off by a factor of two, change the number of pulses per revolution to make the RPM read correctly. The engine frequency, Channel 11, is combined with the pulses per revolution number in Channel 83 to make the appropriate engine speed calculation in Channel 125. When using a direct tach lead or optical tach sensor on channel 9, the value entered in Channel 83 is used to obtain a correct factor for proper RPM calculation in channel 125. Table 9-1: shows examples of how this works.

Table 9-1: Inductive Pickup Pulse per Revolution

IGNITION PULSES					
	Wasted spark	Wasted Spark	No Wasted Spark	No Wasted Spark	Units
Channel 11 Frequency from the pickup	50	25	25	12.5	Hz
Channel 83 Pulses per Rev	1	1	0.5	0.5	Ratio
Factor to convert Frequency in seconds to minutes	60	60	60	60	Multiplier
Resultant RPM	3000	1500	3000	1500	RPM

Channel 84 - TirDia **Default Value 24.000 *[61]***

Channel 84 is used to enter the tire diameter in inches *[cm]*. This information is used for calculating the wheel slip in Channel 53. The tire diameter information is combined with the wheel revolutions in Channel 56 to determine a wheel speed, Channel 57, derived from the optical tach input, channel 12. If wheel slip is apparent under no load, it may be necessary to adjust the effective tire diameter to reduce the slip to zero at light loads. Tires tend to change their effective rolling diameter under high rates of acceleration or deceleration, and this is an interesting result to view on plots during a test. If the average number is not zero, change the entered tire diameter in this channel to change the average value to zero. The average effective rolling diameter is usually about 1" *[25 mm]* less than the measured diameter. There is a test profile provided (**Tir_Dia**) that will automatically provide the correct tire diameter value when the test is run using the optical tach. The tire diameter is also required when using the Calculated Engine Speed method to obtain engine RPM. See channel 125.

Channel 85 - IgnPck **Default Value 1**

Channel 85 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables input signals from channel 11, an inductive spark pickup, coil pick-up, or direct tach wire connection. It may also be used with the 1200A-2448-1 optical tach cable. A zero (0) in this channel will disable channel 11 inputs to the calculations in channel 125.

Channel 86 - OpTach **Default Value 0**

Channel 86 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables input signals from an optical speed sensor using cable 1200A-2448-1. A zero (0) in this channel will disable optical tach sensor inputs to the calculations in channel 125.

Channel 87 - CalTac **Default Value 0**

Channel 87 is used to select the engine speed calculation method desired for channel 125. A one (1) in this channel enables engine speed calculations with no signal input device, instead using roll speed in MPH, tire diameter, and a RPM ratio. A zero (0) in this channel will disable these calculations in channel 125.

Channel 88 - FWD **Default Value 1**

Used only on AWD systems

Channel 88 is used to select whether the front rollset power calculations are to be used on the AWD system. A zero in this channel disables the front rollset power calculations in the final wheel power calculation. This channel is not used on the 2WD or AD-11 systems. See Table 9-2: for the various modes available on the AWD system.

Table 9-2: AWD Modes of Operation

Mode	Rolls used and wheel positions	Channel 88 FWD	Channel 89 RWD	Horsepower Calculated by channel 100, WhlPwr
1	Both rolls used, wheels on both rolls. Mode used for AWD vehicles. May also be used for 2WD vehicles.	1	1	Channel 100 calculates total power available to move the vehicle, torque split channel is valid for AWD vehicles. For 2WD vehicles, the torque split will be misleading, as losses from the non-driven wheels will be incorporated into the calculation.
2	Both rolls used, wheels on both rolls. Mode used for front wheel drive vehicles.	1	0	Channel 100 calculates power available at the front wheels only. Although the rear wheels are on the rear roll, any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The front load cell will calculate appropriate losses from the rear rollset.
3	Both rolls used, wheels on both rolls. Mode used for rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. Although the front wheels are on the front roll, any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.
4	Front roll used, rear wheels off rear roll. Mode is used for front wheel drive vehicles.	1	0	Channel 100 calculates power available at the front wheels only. The rear wheels are off the rear roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The front load cell will calculate appropriate losses from the rear rollset.
5	Rear roll used, front wheels off front roll. Mode is used for rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. The front wheels are off the front roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.
6	Rear roll used, front wheels off front roll. Front rollset driveshaft disconnected. Mode is used for extra long rear wheel drive vehicles.	0	1	Channel 100 calculates power available at the rear wheels only. The front wheels are off the front roll. Any power derived at that roll, positive or negative, is ignored in the wheel power calculation. The rear load cell will calculate appropriate losses from the front rollset.

Channel 89 - RWD **Default Value 1**

Used only on AWD systems

Channel 89 is used to select whether the rear rollset power calculations are to be used on the AWD system. A zero in this channel disables the rear rollset power calculations in the final wheel power calculation. This channel is not used on the 2WD or AD-11 systems. See Table 9-2: for the various modes available on the AWD system.

Channel 90 - IntFw **Default Value 0**

Used only on AWD systems

Channel 90 is used in channel 39 to add an approximate front wheel assembly inertia to the inertia power calculation for the front wheels on AWD systems. The value is equivalent rotating mass in pounds. It is recommended to use the default value unless you have a more accurate number from the vehicle manufacturer or have an accurate way to measure the rolling inertia of the front wheel assembly. Leaving the value at zero will allow the inertia power channel to calculate the actual power imparted to the roll, without being influenced by the front wheel assembly inertia. In this mode, tests run at varying rates of acceleration will produce slightly different power results. If you do apply an accurate front wheel assembly inertia value, then the inertia power numbers will generally match regardless of the rate of acceleration. This number is not used on 2WD systems or when running only 2 wheels on an AWD system.

Channel 91 - IntRw **Default Value 0**

Channel 91 is used in channel 43 to add an approximate rear wheel assembly inertia to the inertia power calculation for the rear wheels on all systems. The value is equivalent rotating mass in pounds. It is recommended to use the default value unless you have a more accurate number from the vehicle manufacturer or have an accurate way to measure the rolling inertia of the rear wheel assembly. Leaving the value at zero will allow the inertia power channel to calculate the actual power imparted to the roll, without being influenced by the rear wheel assembly inertia. In this mode, tests run at varying rates of acceleration will produce slightly different power results. If you do apply an accurate rear wheel assembly inertia value, then the inertia power numbers will generally match regardless of the rate of acceleration.

Channel 93 - Recpcl **Default Value 1.000**

Channel 93 is a reciprocal value used by the Pro Filter feature to properly calculate engine speed increments when using the optical tach or calculated RPM methods. This value is controlled and computed by the acceleration test profiles. It should not be altered by the user.

Channel 94 - RpmRat **Default Value 1.000**

Channel 94 is the ratio used by channel 125 for calculating engine speed when using the optical tach or calculated engine speed methods. This ratio is computed automatically when the **EngSpd** test profile is run to select the engine speed method. Unless the exact ratio is known, it is recommended to run the **EngSpd** test profile and allow the system to set this ratio.

Channel 95 - Start **Default Value 40.000 *[60]***

Channel 95 is for entering the start speed to use in various automated tests. It may be changed from the Handheld Controller before starting the automated test as required. It will then be re-stored in Channel 95 by the automated test.

Channel 96 - StopAt **Default Value 100.00 *[160]***

Channel 96 is for entering the speed for stopping an automatic test. When the test is run, it may be altered by the Handheld Controller. The new value will be re-entered in Channel 96.

Channel 97 - StepTm **Default Value 20.000**

Channel 97 is used to enter the step time in seconds for the various automated tests. The step time may be modified from the Handheld Controller during most autotests as required. The new value will then be entered into Channel 97 automatically.

Channel 98 - StpSiz **Default Value 10.000**

Channel 98 is used to enter the requested step size for step changes in automated test profiles. The step size may be modified from the Handheld Controller before the test begins, and the new value will be entered into Channel 98 automatically.

9.2.3 Calculated Channels

The calculated channel is one of the most powerful features of the WinDyn software. Sensor data, specifications, interpolation tables, another calculation, and/or any direct constant value can be combined into a mathematical calculation to produce real time data that will be displayed and recorded along with the rest of the test data. Channel 100 through 129 are dedicated calculated channels. Additionally, any measured channel may be configured as a calculated channel although it is not recommended to create them in channel blocks used for installed measured channels. For instance, if a thermocouple module is installed in channels 13-28, do not make channel 25 a calculated channel. However, if the thermocouple module was not installed, any or all channels 13-28 could be used for additional calculated channels. Any predefined calculated channel may easily be modified using the configuration editor supplied with WinDyn.

The calculation formula is shown next to the channel name.

Channel 3 - TrqAbs **C2abs**

(2WD systems only)

Channel 3 is used on 2WD systems as a calculated channel used to display the absolute value from channel 2, Trq1. This allows reverse rotation of the rollset without recalibration. This channel is defined as a control channel (for the road load simulation test). It has control values set at -9999 minimum and +9999 maximum.

Channel 37 - RwAbPw **HP = C2*C123/5252.113**
kW = C2*C123/9549

Used only on AWD

Channel 37 is used to calculate the power absorbed by the strain gage attached to the rear differential. It uses the power absorber torque from Channel 2 times the roll RPM from Channel 123, and divides by a constant to determine the power absorbed. This value is combined with channels 43 and 44 in channel 42 to calculate rear wheel power. When the eddy current absorber is loaded during a test, this channel will contribute a larger portion to the rear wheel power calculation in channel 42. When using the AWD dyno in 2WD mode, by not placing the vehicle front wheels on the front rollset, this channel will also calculate all losses due to the rear drive wheels now spinning the front rollset. Thus, no front rollset losses or inertia calculations are necessary. This also enables use of the dyno without the front rollset connected via its driveshaft.

Channel 38 - FwRlPw **C39+C40+C41**

Used only on AWD

Channel 38 is used to calculate the measured wheel power delivered to the front dynamometer roll. Channel 41, the eddy current absorber power, is added to Channel 39, the inertia power due to acceleration, and Channel 40, the dynamometer parasitic power loss. *Some* ***inertia only*** *dynamometers use only the inertia power, leading to measurement errors.* This channel and channel 42 are added together to derive total wheel power.

Channel 39 - FwInPw **HP = (1651+C90)*C122*C10/375**
kW = ((1651*0.454)+C90)*9.91*C122*C10/3600

Used only on AWD

Channel 39 is used to calculate the front rollset inertia power during a transient test. When the vehicle is accelerating or decelerating, additional power is developed by the engine to accelerate the inertia of the roll, the absorber, and the rotating components of the vehicle. Inertia power is calculated from the front rollset inertia of the dynamometer (1651 lbs), the rotating inertia of the front wheels of the vehicle (channel 90), the rate of acceleration in G's from Channel 122, and the actual road speed from Channel 10. The inertia power is used by Channel 38 to determine the total front wheel power. The default value of 1651 is the inertia value for a typical front rollset. Individual customer systems will require their specific rollset value to be entered into this channel. This will be done during initial testing at SuperFlow and can be verified by the customer calibration data sheet shipped with the system. The value is equivalent vehicle mass in pounds. This value should match the calibration sheet shipped with your system. **DO NOT CHANGE THIS VALUE.** Doing so will severely alter all power readings from the system. The constant 375 comes from the standard horsepower equation constant that uses 33,000 lbs-ft/min. By dividing 33,000 by 5280 and then multiplying by 60, you get 375. This converts to lbs-miles/hour, which works with the MPH value from channel 10.

Channel 40 - FwRLos **HP = (C10T133)*C119/0.0763**
kW = ((C10T133)*C119/1.293)*0.746

Used only on AWD

Channel 40 is used to calculate the parasitic losses inherent in the front rollset of the dynamometer due to aerodynamic drag. This channel uses the roll speed, and then refers to interpolation table 133. These losses are measured at the SuperFlow factory by motoring the dynamometer at all speeds up to 200 miles per hour *[320 km/h]* and recording the loss information. Channel C119 adjusts the roll aerodynamic losses for air density. The value 0.0763 is a constant relating to standard air density. Channel 40 is combined with channels 39 and 41 in channel 38 to calculate front wheel power.

Channel 41 - FwAbPw **HP = C3*C123/5252.113**
kW = C3*C123/9549

Used only on AWD

Channel 41 is used to calculate the power absorbed by the strain gage attached to the front differential. It uses the power absorber torque from Channel 3 times the roll RPM from Channel 123, and divides by a constant to determine the power absorbed. This value is combined with channels 39 and 40 in channel 38 to calculate front wheel power. When the eddy current absorber is loaded during a test, this channel will contribute a larger portion to the front wheel power calculation in channel 38.

Channel 42 - RwRlPw **C43+C44+C37**

Used only on AWD

Channel 42 is used to calculate the measured wheel power delivered to the rear dynamometer roll. Channel 37, the eddy current absorber power, is added to Channel 43, the inertia power due to acceleration, and Channel 44, the dynamometer parasitic power loss. *Some* ***inertia only*** *dynamometers use only the inertia power, leading to measurement errors.* This channel and channel 38 are added together to derive total wheel power.

Channel 43 - RwInPw **HP = (2102+C91)*C122*C10/375**
kW = ((1651*0.454)+C91)*9.91*C122*C10/3600

Used only on AWD

Channel 43 is used to calculate the rear rollset inertia power during a transient test. When the vehicle is accelerating or decelerating, additional power is developed by the engine to accelerate the inertia of the roll, the absorber, and the rotating components of the vehicle. Inertia power is calculated from the rear rollset inertia of the dynamometer (2102 lbs), the rotating inertia of the rear wheels of the vehicle (channel 91), the rate of acceleration in G's from Channel 122, and the actual road speed from Channel 10. The inertia power is used by Channel 42 to determine the total rear wheel power. The default value of 2102 is the inertia value for a typical rear rollset. Individual customer systems will require their specific rollset value to be entered into this channel. This will be done during initial testing at SuperFlow and can be verified by the customer calibration data sheet shipped with the system. The value is equivalent vehicle mass in pounds. This value should match the calibration sheet shipped with your system. **DO NOT CHANGE THIS VALUE.** Doing so will severely alter all power readings from the system. The constant 375 comes from the standard horsepower equation constant that uses 33,000 lbs-ft/min. By dividing 33,000 by 5280 and then multiplying by 60, you get 375. This converts to lbs-miles/hour, which works with the MPH value from channel 10.

Channel 44 - RWRlos **HP = (C10T132)*C119/0.0763**
kW = ((C10T132)*C119/1.293)*0.746

Used only on AWD

Channel 44 is used to calculate the parasitic losses inherent in the rear rollset of the dynamometer due to aerodynamic drag. This channel uses the roll speed, and then refers to interpolation table 132. These losses are measured at the SuperFlow factory by motoring the dynamometer at all speeds up to 200 miles per hour *[320 km/h]* and recording the loss information. Channel C119 adjusts the roll aerodynamic losses for air density. The value 0.0763 is a constant relating to standard air density. Channel 44 is combined with channels 37 and 43 in channel 42 to calculate rear wheel power.

Channel 45 - TrqSpt **((C42*C88*C89)/C100)*100**

Used only on AWD

Channel 45 is used to calculate the torque split between the front and rear drive systems on an AWD vehicle. It uses the rear wheel power channel 42 divided by the total wheel power channel 100. That value is then multiplied by 100 to obtain a percentage value. Channels 88 and 89 are used as switches to enable this channel's output. The torque split value will only be valid when using the dyno system to measure power in the AWD mode (C88 and C89 both = 1). In all other modes, the torque split value will be invalid and will be set to zero.

Channel 50 - CWhlPw **C113**

Channel 50 is a corrected wheel power channel used with previous AutoDyn configuration files. It is made available for direct comparison with previous saved data files. The value is the same as that displayed in channel 113, STPPwr.

Channel 51 - TrnSlp **(C125-(C52*C79*C80))/C125*100**

Channel 51 is used to estimate the transmission slip that occurs during a test. It takes the difference between the shaft revolutions measured by the optical tachometer in Channel 52 and the engine speed in Channel 125. This difference is converted into a percent slip number. This channel is useful in determining when a torque converter is locking up. The addition of channels 85 and 87 is used to disable this channel when the optical tach is used for measuring engine speed.

Channel 52 - ShftRv **C56*C81**

Channel 52 is used to determine driveshaft revolutions using the wheel revolutions channel, C56, and multiplying by the rear differential gear ratio.

Channel 53 - WhlSlp (C57-C10)/C10*100

Channel 53 is used to estimate the wheel slip that occurs during a test. It takes the difference between the wheel speed measured by the optical tachometer in Channel 57 and the roll speed in Channel 10. This difference is converted into a percent slip number. The slip value will usually be low (less than 1%) at low rates of acceleration or at constant speed. Under high acceleration or deceleration, some slip will appear (less than 5%). If the slip is greater than zero at low loads, it is probable that the tire diameter information used by Channel 57 is incorrect for the vehicle. The tire diameter information comes from the specifications in Channel 84. Change the tire diameter until the average slip is zero at constant speed and no load. This is the effective rolling diameter of the tire. Use the **Tir_Dia** test profile to facilitate obtaining the correct tire diameter.

Channel 54 - Rv/mph C125/C10
Rv/kmh C125/C10

Channel 54 calculates the ratio of the engine speed to the roll speed during a test. This ratio is useful for observing potential wheel slip, clutch slip, or tire slippage during changes in speed. During fast transients, some change in the ratio can also be introduced if there are different data filtration rates on the engine tachometer versus the roll speed, however, this would not be the normal condition.

Channel 55 - OvrRat C79*C80*81

Channel 55 calculates the overall ratio of all gears from crankshaft to the driven wheel of the vehicle under test. Engine ratio, transmission ratio, and final drive ratio are multiplied together to obtain the overall ratio.

Channel 56 - WhelRv C12*60

Channel 56 is used to calculate the wheel rpm based on the optical tachometer signal from Channel 12. Channel 56 is used by Channel 57 to calculate the actual wheel speed in miles per hour *[km/h]* from the optical tachometer input.

Channel 57 - WhlSpd
mph = (C56*C84/12*3.1416*60/5280)
km/h = (C56*C84*3.1416*60/100000)

Channel 57 is used to calculate the wheel speed in miles per hour *[km/h]* from the optical tachometer input on Channel 12 and calculations in Channel 56. Channel 84, the tire diameter, is used to convert the wheel rpm to miles per hour *[km/h]*.

Channel 58 - WhRvPm (C10/60)*(5280/(C84*0.2618))
(C10/60)*(1000/(C84*3.14/1000))

Channel 58 calculates the wheel revolutions per minute using the roll speed (C10) and tire diameter (C84). The constant 0.2618 equals Pi divided by 12 and is used to simplify the equation for WinDyn. Channel 58 can then be used to derive engine speed in channel 125 without using any type of sensor.

Channel 59 - OptRpm C9*60

Channel 59 is used to calculate optical RPM when using the 1200A-2448-1 optical cable for engine speed calculations. The cable is used in the channel 11 jack, but the signal appears on the channel 9 frequency channel. Since the frequency is in hertz, it must be multiplied by 60 to get pulses per minute instead of pulses per second.

Channel 60 - OilTmp C5T136

Channel 60 is used to calculate the engine oil temperature using our Oil Dipstick Probe. The voltage from channel 5 is converted using table 136 to produce a temperature value. Fahrenheit or Celsius readings are determined by the values entered into Interpolation Table 136. This channel should be deleted for systems equipped with a thermocouple module to measure temperatures.

Channel 74 - AirInT C1T136

Channel 74 displays the air inlet temperature from the thermistor used for ambient air temperature measurement. The thermistor is located inside the humidity probe and should be positioned near the intake air for the engine. The voltage from channel 1 is converted using table 136 to produce a temperature value. Fahrenheit or Celsius readings are determined by the values entered into Interpolation Table 136. The air temperature data is used to determine power correction factors and air density.

Channel 75 - DifTmp C71T136

Channel 75 displays the differential temperature from the thermistor embedded in the rollset differential. The voltage from channel 5 is converted using table 136 to produce a temperature value. Fahrenheit or Celsius readings are determined by the values entered into Interpolation Table 136. The rollset should not be operated if temperatures exceed 200 degrees Fahrenheit.

Channel 100 - WhlPwr C108 + C105 + C126

Channel 100 is used to calculate the measured wheel power delivered to the dynamometer roll. Channel 126, the eddy current absorber power, is added to Channel 108, the inertia power due to acceleration, and Channel 105, the dynamometer parasitic power loss. *Some **inertia only** dynamometers use only the inertia power, leading to measurement errors.* All corrected power and all wheel torque numbers are derived from this channel.

Channel 101 - SAECor ((459.7+C74)/536.7)^0.5*(29.23/(C76-C118))
k ECE (99/(C76-C118))^1.2*((C74+273)/298)^0.6

Channel 101 is used to calculate the Society of Automotive Engineers (SAE) or Economic Commission of Europe (ECE) power correction factor for the engine under test. It combines the ambient air temperature from Channel 74 and the barometric pressure from Channel 76 with the vapor pressure of the moisture of the air from Channel 118. The factor corrects the power to the estimated power at 77^0 Fahrenheit *[25^0 C]* and 29.23 inches of mercury *[99 kPa]* air pressure. The SAE *[ECE]* Correction Factor is used by Channel 112, SAEPwr *[ECEPwr]*, to correct the Wheel Power in channel 100.

Channel 102 - STPCor ((459.7+C74)/519.7^0.5*(29.92/C76-C118))
k DIN (101.3/C76-C118)*((C74+276)/293)^0.5

Channel 102 is used to calculate the Standard Temperature and Pressure (STP) or Deutsche Industrie Norm (DIN) power correction factor. It uses the ambient air temperature from Channel 74, the barometric pressure from Channel 76, and the vapor pressure from Channel 118 to calculate a power correction factor. The factor corrects the power to the estimated power at 60^{o} Fahrenheit *[20^{o} C]* and 29.92 inches of mercury *[101.3 kPa]* barometric pressure. Channel 102 is used by Channel 113, STPPwr *[DINPwr]*, to correct the Wheel Power in channel 100.

The correction factors listed here are the default formulas provided by Superflow. WinDyn is capable of generating performance data corrected to any standard. All that is required is to change the name and formula in one of these channels. The channel names of the referenced channels (xxxPwr and xxxTrq) should also be changed to reflect the proper correction standard.

Channel 103 - TotTrq C2 +C3
Used only on AWD systems

Channel 103 calculates the total absorber torque on AWD systems. This value is use for Roadload and Aero acceleration tests. The channel is defined as a control channel in the AWD system, with a minimum value of 0 and a maximum value of 9999. This channel is unused on 2WD and AD-11 systems.

Channel 104 - A/F (C4*2)+9

Channel 104 is used to calculate the Lambda Air Fuel ratio. It uses the voltage input from channel 4 and then applies that voltage to a standard calculation for the A/F device. It is currently defined for use with Tech Edge Lambda sensor inputs. The channel is set to produce an air fuel ratio value using the calculation (V*2)+9 and does not require calibration. If using the Tech Edge product to measure methanol air fuel ratio, then the channel may be redefined to match the calculation (V*0.871)+3.92. Typical values range from 9-19 for gasoline engines, with typical best performance achieved in the range of 12-14. For methanol, values range from 3.92 to 8.27. The formula may be changed for different A/F devices if necessary. If using the AFM1000 lambda device, the calculation should be changed to (V*2)+8. If using the AFM 1000 to measure methanol air fuel ratio, then the channel may be redefined to match the calculation (V*0.888)+3.55. Typical values range from 8-18 for gasoline engines, with typical best performance achieved in the range of 12-14. For methanol, values range from 3.55 to 7.99.

Channel 105 - DynLos

2WD and AD-11 Systems

HP = ((C10T132)*C119/0.0763)

kW = ((C10T132)*C119/1.293)*0.746

Channel 105 is used to calculate the parasitic losses inherent in the dynamometer due to aerodynamic drag. This channel uses the roll speed, and then refers to interpolation table 132. These losses are measured at the SuperFlow factory by motoring the dynamometer at all speeds up to 200 miles per hour *[320 km/h]* and recording the loss information. Channel C119 adjusts the absorber and roll aerodynamic losses for air density. The value 0.0763 is a constant relating to standard air density. Channel 105 is combined with channels 126 and 108 in channel 100 to calculate wheel power. It is also used in channel 127 to calculate coastdown losses and in channel 129 for use in the Roadload and Aero simulations.

AWD systems (C40*C88)+(C44*C89)

For AWD systems, the front roll loss (C40) is added to the rear roll loss (C44) to produce total dyno losses. Channels 88 and 89 are used as switches for selecting the wheel power measurement mode on the AWD system. This value is combined with channels 108 and 126 in channel 100 to calculate wheel power.

Channel 106 - TirLos

2WD and AD-11 Systems

HP = (C77/2)*0.010*C10/375

kW = (C77/2)*0.010*9.81*C10/3600

AWD Systems

HP = ((C77/2)*0.010*C10/375)*(((C88*C89)-1)abs)

kW = ((C77/2)*0.010*9.81*C10/3600)*(((C88*C89)-1)abs)

Channel 106 is used to calculate the estimated rolling power losses of the non-driven tire. Rolling losses are a function of the weight on the tire and the tire loss coefficient of 0.010. Channel 106 is then used by Channel 129 to calculate the required absorber torque to apply during the Road Load simulation tests. The additional portion of the calculation, ((C88*C89)-1)abs), is used on the AWD systems to turn off the calculation when both front and rear wheels are used on the rollsets. In that case, since both front and rear wheels are being driven on the rollsets, their inherent losses will already be present to the system and there is no need to estimate tire loss.

Channel 107 - AirDrg **hp = 1.055*C78*(C10^3)*C119/10000**

kw = (1.29)*(C10^3)*C119*C78/100000

Channel 107 is used to calculate the air drag power for the vehicle. This channel uses Channel 78 for vehicle frontal area times the coefficient of drag, and Channel 119 for air density. These are all multiplied by the cube of the vehicle speed, Channel 10, to determine the air drag power at any speed during a test. These figures are used by Channel 129 to determine the correct road load power for Road Load test simulations.

Channel 108 - InrPwr

2WD Systems

HP = (2200+C91)*C122*C10/375

kW = ((2200*0.454)+C91)*9.81*C122*C10/3600

AD-11 Systems

HP = (800+C91)*C122*C10/375

kW = ((800*0.454)+C91)*9.91*C122*C10/3600

Channel 108 is used to calculate the inertia power during a transient test. When the vehicle is accelerating or decelerating, additional power is developed by the engine to accelerate the inertia of the roll, the absorber, and the rotating components of the vehicle. Inertia power is calculated from the base inertia of the dynamometer, the rotating inertia of the vehicle (defaulted to a value of 0 in channel 91, but may be changed if desired), the rate of acceleration in G's from Channel 122, and the actual road speed from Channel 10. The inertia power is used by Channel 100 to determine the total wheel power. The default value of 2200 (800 for AD-11) is the inertia value for a typical rear rollset. Individual customer systems will require their specific rollset value to be entered into this channel. This will be done during initial testing at SuperFlow and can be verified by the customer calibration data sheet shipped with the system. The value is equivalent vehicle mass in pounds. This value should match the calibration sheet shipped with your system. DO NOT CHANGE THIS VALUE. Doing so will severely alter all power readings from the system. The constant 375 comes from the standard horsepower equation constant that uses 33,000 lbs-ft/min. By dividing 33,000 by 5280 and then multiplying by 60, you get 375. This converts to lbs-miles/hour, which works with the MPH value from channel 10.

AWD Systems (C39*C88) + (C43*C89)

On AWD systems, channel 108 calculates total inertia power by adding together the front rollset inertia power, channel 39, and the rear rollset inertia power, channel 43. Channels 88 and 89 are used as switches for selecting the wheel power measurement mode on the AWD system. This value is combined with channels 126 and 105 in channel 100 to calculate wheel power.

Channel 109 - DstncF C225*5280

Channel 109 calculates distance traveled in feet. Memory channel 5 (C225) is a system channel that continually calculates distance in miles. This channel is used in the Road Load simulation test. It may also be used in any other test profile by simply adding a command to preset Memory 5 to zero prior to starting the test. All current test profiles reset memory channel 5 at the beginning of each test.

Channel 110 - DstncM C225

Channel 110 calculates distance traveled in miles. Memory channel 5 (C225) is a system channel that continually calculates distance in miles. However, the decimal units displayed on channel 225 is in whole units and cannot be changed. Channel 110 allows the reading to be viewed in tenths of a mile. This channel is used in the Road Load simulation test. It may also be used in any other test profile by simply adding a command to preset Memory 5 to zero prior to starting the test. All current test profiles reset memory channel 5 at the beginning of each test.

Channel 111 - ElpsTm **C211**

Channel 111 uses Timer 2, channel 211, to measure elapsed time in seconds during a test profile. It allows decimal precision adjustments, if desired.

Channel 112 - SAEPwr **C100*C101**
ECEPwr

Channel 112 is used to calculate the “corrected” rear wheel power for the test vehicle. Channel 100, the rear wheel power, is multiplied times Channel 101, the SAE *[ECE]* Temperature and Pressure Correction Factor. The SAECor *[kECE]* correction Factor, Channel 101, is for estimating what the power would have been at 77^{0}F *[25 ^{o}C]* air temperature and 29.23 in.Hg *[99kPa]* barometric pressure in dry air.

Channel 113 - STPPwr **C100*C102**
DINPwr

Channel 113 is used to calculate the “corrected” rear wheel power for the test vehicle. Channel 100, the rear wheel power, is multiplied times Channel 102, the STP *[DIN]* Temperature and Pressure Correction Factor. The STPCor *[k DIN]* correction Factor, Channel 102, is for estimating what the power would have been at 60^{0}F *[20 ^{o}C]* air temperature and 29.92 in.Hg *[101.3kPa]* barometric pressure in dry air.

Channel 114 - DJWhPw **C112*C82**

Channel 114 is used to calculate a “comparison” rear wheel power for the test vehicle. Channel 112, the SAE *[ECE]* corrected rear wheel power, is multiplied times Channel 82, DJCorF, the dyno comparison factor. Channel 114, is for estimating what the power would have been on a competitor's dyno at 77^{0}F *[25 ^{o}C]* air temperature and 29.23 in.Hg *[99kPa]* barometric pressure in dry air. This channel is an estimate only, used for comparisons with another dyno, and should not be used for marketing or development purposes.

Channel 115 - SAETrq **lb-ft = C112*5252.113/C125**
nm = C112*9549/C125

Channel 115 derives a corrected torque value in lb-ft *[nm]* from the SAE *[ECE]* corrected power calculated at the rear wheel in channel 112, using Engine Speed from channel 125. Although this is not the actual torque applied to the ground, it is a common value used in marketing and advertising to represent corrected torque of the vehicle under test.

Channel 116 - STPTrq **lb-ft = C113*5252.113/C125**
nm = C113*9549/C125

Channel 116 derives a corrected torque value in lb-ft *[nm]* from the STP *[DIN]* corrected power calculated at the rear wheel in channel 113, using Engine Speed from channel 125. Although this is not the actual torque applied to the ground, it is a common value used in marketing and advertising to represent corrected torque of the vehicle under test.

Channel 117 - DJWhTq **lb-ft = C114*5252.113/C125**
nm = C114*9549/C125

Channel 117 derives a corrected torque value in lb-ft *[nm]* from the dyno comparison corrected wheel power calculated at the rear wheel in channel 114, using Engine Speed from channel 125. This channel is an estimate only, used for comparisons with another dyno, and should not be used for marketing or development purposes.

Channel 118 - Vap P **C74T137*C120/100**

Channel 118 is to calculate the vapor pressure of the water in the air under the test conditions. The percent humidity calculated in Channel 120 is combined with the 100% humidity data generated by Channel 74, the air temperature, and T137, the Interpolation Table Channel. T137 contains the vapor pressure for 100% relative humidity at each temperature. Then Channel 120, the percent relative humidity, is multiplied times that number to obtain the actual vapor pressure. The vapor pressure is then subtracted from the barometric pressure to determine the net barometric pressure to be used in the power correction factors in Channels 101 and 102. Vapor pressure is the true measure of water vapor content of the air. Relative humidity cannot be used directly because it varies with air temperature.

Channel 119 - AirDen **lb/ft^3 = 0.0763*C76/29.92*520/(460+C74)**
g/l = 1.293*C76/101.3*273/(273+C74)

Channel 119 is used to calculate the air density under the test conditions. Air density is measured in pounds per cubic feet *[grams per liter]* of air. The constant 0.0763 is the lbs/cubic foot of air at sea level (1.293 g/l at sea level). Channel 119 uses the barometric pressure from Channel 76 and the air temperature from Channel 74 to calculate the actual air density under test conditions.

Channel 120 - Humidy **(C6-0.655)/2.54*100)/(1.093-(0.0012*C74)**
((C6-0.655)*39.37)/(1.093-(0.00216*C74+0.0384))

Channel 120 takes the humidity sensor voltage input from Channel 6, and combines it with the air temperature to determine the percent relative humidity of the air during the test. This data is then used by Channel 118 to determine the vapor pressure in the air for power correction.

Channel 121 - WhlTrq **lb-ft = C100*5252.113/C125**
nm = C100*9549/C125

Channel 121 derives an uncorrected torque value in lb-ft *[nm]* from the Wheel Power measured at the rear wheel in channel 100, using Engine Speed from channel 125. Although this is not the actual torque applied to the ground, it is a common value used in marketing and advertising to represent torque of the vehicle under test.

Channel 122 - Accel **C220/21.937**

Channel 122 calculates the actual acceleration or deceleration of the test vehicle in G's. It uses Channel 220, which calculates the acceleration in miles per hour per second, and converts it to G's by dividing by 21.937. One G is equal to an acceleration rate of 21.937 miles per hour per second *[9,807 meters per second per second]*.

Channel 123 - RolRPM **C10*5280/60/42/3.1416*12**
C10*1000/60/50.4/3.1416*100

Channel 123 is used to calculate the roll rpm during a test. It determines the roll rpm from the roll speed from Channel 10 by calculating the circumference of the roll and dividing it into the distance traveled per revolution at that speed.

Channel 125 - EngSpd
(C85*(C11+C9)/C83*60)+((C86*C59)+(C87*C58)*C94)

Channel 125 is used to calculate the engine speed. It uses several methods to do this, determined by the settings of channels 85, 86, and 87. Whichever one of those channels is set to a value of 1 (with the other two set to a zero) will determine which calculation to be used. The first portion uses the frequency input from Channel 11, the ignition pickup or Channel 9, the tachometer direct input, divided by the pulses per revolution of the engine, Channel 83. These are multiplied by 60 to convert the pulses per second to pulses per minute for RPM. Channel 83 can also be used as a factor if you are using the direct tachwire pickup. The second portion of the equation uses the frequency from the optical tach pickup, channel 9, along with a ratio of the rotating device to the engine's rotation. The optical tach could be used on any rotating device on the engine and the ratio should then be the ratio of that device to the engine. The third portion of the equation simply calculates engine speed in a specific transmission gear ratio as a function of roll speed. It requires no specific pickups.

Channel 126 - AbsPwr

2WD and AD-11 systems

HP = C3*C123/5252.113
kW = C3*C123/9549

Channel 126 is used to calculate the power absorbed by the eddy current power absorber. It uses the power absorber torque (in absolute value) from Channel 3 times the roll RPM from Channel 123, and divides by a constant to determine the power absorbed. This value is combined with channels 108 and 105 in channel 100 to calculate wheel power. When the eddy current absorber is loaded during a test, this channel will contribute a larger portion to the wheel power calculation in channel 100.

AWD systems

(C41*C88) + (C37*C89)

For AWD systems, the front absorber power, channel 41, and rear absorber power, channel 37, are simply added together to provide total absorber power. Channels 88 and 89 are used as switches for selecting the wheel power measurement mode on the AWD system. This value is combined with channels 108 and 105 in channel 100 to calculate wheel power.

Channel 127 - CsDnLs **C108+C105+C126**

Channel 127 is used to calculate the estimated power losses, or coast-down losses for the vehicle under test. It should only be used for the results of an automated coast-down test to determine the losses of the vehicle at various speeds. It uses Channel 108, the inertia power for the test, and adds on the internal dyno losses plus the frictional power measured by the strain gauge. The result is the total power being removed from the vehicle as it coasts-down at each speed. This is not equal to the total power loss of the vehicle when it is actually running under power because the transmitted power is less during coast-down.

Channel 128 - GrndTq

2WD and AWD

Clb-ft = C113*5252.113/C123/42*C84

CNm = C113*9549/C123/1066.8C84

AD-11 only

Clb-ft = C113*5252.113/C123/12.73*C84

CNm = C113*9549/C123/323.34*C84

Channel 128 is used to calculate the corrected wheel torque actually applied to the ground, derived from the STP corrected wheel power in channel 113. This value will change based upon the vehicle gear ratio or tire diameter used during the test. Lower numbered gears will produced higher values. For 2WD and AWD systems, the roll diameter is 42 inches. For the AD-11 systems, the roll diameter is 12.73 inches.

Channel 129 - CEcTq1 **lb-ft = (C106+C107-C105)*5252.113/C123**

nm = (C106+C107-C105)*9549/C123

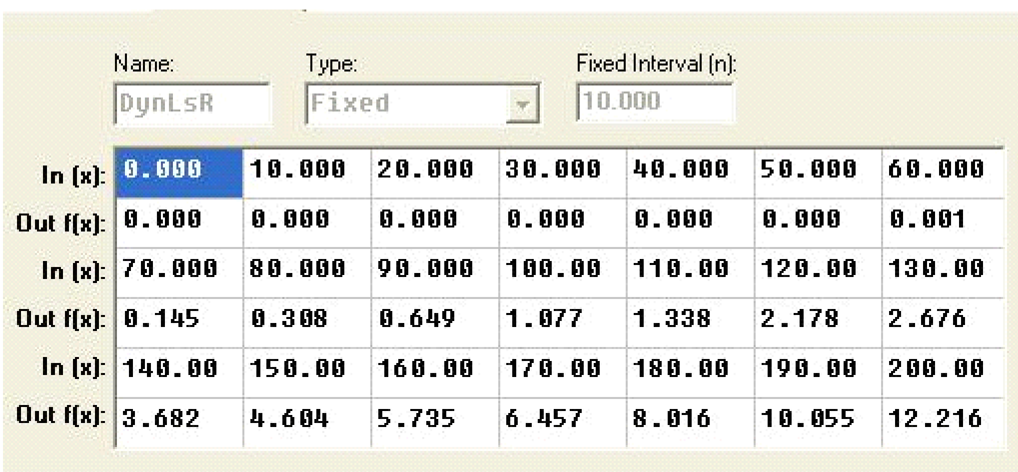
Channel 129 is used to calculate the compensated eddy current torque required to provide different inertia simulations for different weight vehicles. This signal is used to provide control for road power simulations that will duplicate the normal road loads for aerodynamic drag, Channel 107, and tire rolling resistance, Channel 106. Channel 105 is dyno parasitic power loss. Channel 123 is roll rpm. This channel is used exclusively in the Road Load test profile.

9.2.4 Interpolation Tables

Interpolation Tables store non-linear functions for calibration and calculation purposes. Typical uses include the use of calibration tables for air and fuel turbines, parasitic inertia tables for chassis dyno rolls, and correction factor tables. This feature is used to linearize a sensor, or simply to perform calculations from a set of arbitrary data. Tables can be defined with interval or variable interval input values. The Interpolation Tables are located in Channels 130 through 139.

Interpolation Channel 132 - DynLsR 2WD and AWD systems only

Channel 132 is an interpolation look-up table for the aerodynamic losses on the dyno rollset (rear rollset on AWD systems). If speed is delivered to this table, it will return the power loss at that speed. These values were determined and entered after factory testing. Each system may have unique values. Changing the values below will affect the power number calculated in channel 105, DynLos, on 2WD systems and channel 44, RwRlos, on AWD systems. This channel is not used on AD-11 systems. Metric values are not necessary as the formula in channels 44 and 105 convert the loss power to KW in metric configurations.



Name: DynLsR
Type: Fixed
Fixed Interval (n): 10.000

In (x):	0.000	10.000	20.000	30.000	40.000	50.000	60.000
Out f(x):	0.000	0.000	0.000	0.000	0.000	0.000	0.001
In (x):	70.000	80.000	90.000	100.00	110.00	120.00	130.00
Out f(x):	0.145	0.308	0.649	1.077	1.338	2.178	2.676
In (x):	140.00	150.00	160.00	170.00	180.00	190.00	200.00
Out f(x):	3.682	4.604	5.735	6.457	8.016	10.055	12.216

Interpolation Channel 133 - DynLsF AWD systems only

Channel 133 is an interpolation look-up table for the aerodynamic losses on the front rollset of the dyno. If speed is delivered to this table, it will return the power loss at that speed. These values were determined and entered after factory testing. Each system may have unique values. Changing the values below will affect the power number calculated in channel 40 on AWD systems. This channel is not used on 2WD or AD-11 systems. Metric values are not necessary as the formula in channel 40 converts the loss power to KW in metric configurations.

Name: DynLsF Type: Fixed Fixed Interval (n): 10.000

In (x):	0.000	10.000	20.000	30.000	40.000	50.000	60.000
Out f(x):	0.000	0.000	0.000	0.000	0.000	0.000	0.000
In (x):	70.000	80.000	90.000	100.00	110.00	120.00	130.00
Out f(x):	0.000	0.000	0.067	0.635	1.028	1.491	2.234
In (x):	140.00	150.00	160.00	170.00	180.00	190.00	200.00
Out f(x):	3.111	3.978	5.483	6.698	8.402	9.656	11.462

Interpolation Channel 135 - DynLsR AD-11 systems only

Channel 135 is an interpolation look-up table for the aerodynamic losses on the AD-11 dyno rollset. If speed is delivered to this table, it will return the power loss at that speed. These values were determined and entered after factory testing. Each system may have unique values. Changing the values below will affect the power number calculated in channel 105, DynLos, on AD-11 systems.

Name: DynLsR Type: Variable

In (x):	0.000	10.000	20.000	30.000	40.000	50.000	60.000
Out f(x):	0.000	0.190	0.550	1.050	1.730	2.530	3.530
In (x):	70.001	80.001	90.001	100.00	110.00	120.00	130.00
Out f(x):	4.880	6.450	8.430	10.820	13.600	16.780	20.420
In (x):	140.00	150.00	0.000	0.000	0.000	0.000	0.000
Out f(x):	25.440	32.480	0.000	0.000	0.000	0.000	0.000

Interpolation Channel 136 - AirTpT

Channel 136 is an interpolation look-up table to convert the voltage from the air temperature sensor in Channel 1 and the dipstick temp sensor in channel 5 into actual temperature for Channel 74 and 60. Do not modify this table unless you have good calibration data.

US Units (°F)I

Name: AirTpT

Type: Variable

In (x):	0.033	0.086	0.114	0.152	0.206	0.282	0.364
Out f(x):	300.20	230.00	212.00	194.00	176.00	158.00	144.80
In (x):	0.459	0.582	0.738	0.935	1.178	1.471	1.808
Out f(x):	131.60	118.40	105.20	92.002	78.801	65.594	52.400
In (x):	2.178	2.558	2.922	3.245	3.510	3.712	3.857
Out f(x):	39.200	26.000	12.800	-0.400	-13.60	-26.80	-40.00

Metric Units (°C)

Name: AirTpT

Type: Variable

In (x):	0.033	0.086	0.114	0.152	0.206	0.282	0.364
Out f(x):	149.00	110.00	100.00	90.001	80.001	70.001	62.667
In (x):	0.459	0.582	0.738	0.935	1.178	1.471	1.808
Out f(x):	55.333	48.000	40.667	33.333	26.000	18.663	11.333
In (x):	2.178	2.558	2.922	3.245	3.510	3.712	3.857
Out f(x):	4.000	-3.333	-10.66	-18.00	-25.33	-32.66	-40.00

Interpolation Channel 137 - VaporT

Channel 137 is an interpolation look-up table to determine the vapor pressure at 100% relative humidity (saturation vapor pressure) for the dry bulb temperature.

US Units (in/Hg)

Name: VaporT Type: Fixed Fixed Interval (n): 10.000

In (x):	0.000	10.000	20.000	30.000	40.000	50.000	60.000
Out f(x):	0.040	0.070	0.110	0.160	0.250	0.360	0.520
In (x):	70.000	80.000	90.000	100.00	110.00	120.00	130.00
Out f(x):	0.740	1.030	1.420	1.930	2.590	3.440	4.520
In (x):	140.00	150.00	160.00	170.00	180.00	190.00	200.00
Out f(x):	5.870	7.550	9.630	12.180	15.270	18.990	23.450

Metric Units (kPa)

Name: VaporT Type: Variable

In (x):	-1.000	-7.000	-12.00	-18.00	4.000	10.000	16.000
Out f(x):	0.542	0.373	0.237	0.135	0.847	1.219	1.761
In (x):	21.000	27.000	32.000	38.000	43.000	49.000	54.000
Out f(x):	2.506	3.488	4.809	6.536	8.771	11.649	15.306
In (x):	60.000	66.001	71.001	77.001	82.001	88.001	93.001
Out f(x):	19.878	25.567	32.611	41.246	51.710	64.308	79.411

Interpolation Channel 139 - CstDwn

This table is only used when the advanced NGE coastdown feature is enabled through a test profile. Data will be filled in by the coastdown test profile and used temporarily to produce drivetrain parasitic loss data. Default table values will be:

Input = 0-200

Output = all zeros or erratic data

Name: CstDwn | Type: Fixed | Fixed Interval (n): 10.000

In (x):	0.000	10.000	20.000	30.000	40.000	50.000	60.000
Out f(x):	0.000	0.000	0.000	0.000	0.000	0.000	0.000
In (x):	70.000	80.000	90.000	100.00	110.00	120.00	130.00
Out f(x):	0.000	0.000	0.000	0.000	0.000	0.000	0.000
In (x):	140.00	150.00	160.00	170.00	180.00	190.00	200.00
Out f(x):	0.000	0.000	0.000	0.000	0.000	0.000	0.000

9.2.5 System Channels

System Channels are factory preset channels that supply important information to WinDyn. They cannot be modified in any way. The following descriptions lists the system channels and their functions. System Channels can be read and displayed in the same manner as data channels and can be used as operators in calculated channels. System channels cannot be used for closed loop control.

Channel 207 - SetPt1

Channel 207 is the load setpoint used by the eddy current control system. A value is this channel indicates the control setpoint being used. The value changes depending upon the control channel being used. If control is manual, then the value represents a percentage of load from 0-100%. If the control is to Speed, then the value indicates a MPH control point from 0-200 mph. If the control is to TrqAbs, then the value represents a control point from 0 to 9999 lb-ft on the strain gage.

Channel 210 - Timer 1

Channel 210 is a system timer channel. This channel is typically used in test profiles to indicate the total time a test is running. It uses tenths precision.

Channel 211 - Timer 2

Channel 211 is a system timer channel. This channel is typically used in test profiles to indicate ramp time or the time during which the data is collected during a test. It uses tenths precision.

Channel 220 - Memory 0

Channel 220 is acceleration in mph/second. It is used by Channel 122 to calculate acceleration in G's.

Channel 225 - Memory 5

Channel 225 is distance traveled in miles since the last reset of the counter.

Channel 229 - Memory 9

Channel 229 is used by the automated tests to trigger the starting and stopping of the real-time graphs in WinDyn. Do not use this channel for other purposes or this triggering function will be lost.

Channel 231 - LineNo

Channel 231 is a system channel which simply indicates the line number of the data line recorded in a test data file (.sfd).

9.3 Control Channels

Control channels are data channels that can function as closed loop feedback channels. Closed loop feedback channels allow WinDyn to servo (adjust) a control device, such as control on a dynamometer or a throttle actuator to produce a desired value, such as 100 lb-ft of torque or 4000 rpm. The control system uses the control channel to "see" the current value, for example the current torque value, and compares the current value to the desired value. The control system continues to servo the controller (up or down depending on whether the current value is higher or lower than the desired value) until the current value (the value of the control channel) matches desired value. This process of "read current value", "compare to desired value" and "adjust" continues until the control system is placed in manual mode.

Five control channels are available for use by up to two controlled devices, such as dynamometer load and throttle controllers. This allows five different controlled values to be defined for closed loop control. In other words, one or both controllers could be used to execute closed loop control of up to two of five possible values. The combination of a controller controlling a specific value is called a mode. Up to ten different control modes can be used by combining the five control channel values with the two available controllers.

It is not necessary to define all five channels. At a minimum, one channel must be defined if closed loop control is required. Many testing applications use two control channels, one for torque and one for speed. This allows tests to be conducted that control closed loop speed or closed loop torque. The SuperFlow AutoDyn chassis dynamometers uses only one controller (load) but two control channels, roll speed (Channel 10) and roll torque (Channel 129). Testing requirements vary considerably in terms of control requirements.

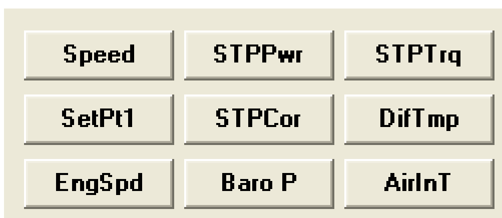
Adding control channels require PID parameters to be created and "tuned". This process is very complicated and should not be attempted by anyone without experience and understanding of PID closed loop servo control.

9.4 Handheld Controller Display Screens

Handheld Controller screens display measured, specification, calculated, and system data channels. The display of 9 channels can be grouped onto 9 separate screens for convenience. The screen design is defined in the configuration file and can be changed as desired.

NOTE: Channels must be defined before data screens can be designed.

The screens are accessed by pressing a number key (1 - 9) on the handheld. A typical screen could be configured as follows:



The screen will display the channel name as well as the data. A pushbutton on the handheld will change the screen to show the units of measurement or the channel number for each channel displayed.

CHAPTER 11

CONTROL MODES

IN THIS CHAPTER

- Introduction
- Control Modes
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- Control Mode Parameters
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  - Delay
- Adjusting Control Mode Parameters
- WinDyn Control File

11.1 Overview

This chapter defines the adjustable control parameters in WinDyn and provides suggestions for tuning the control parameters to provide the best combination for stable, accurate tracking and good step response to set point change.

Because the optimal set of control parameters may vary with engine types or vehicle types, it is useful for the operator to have a good general understanding of how to quickly and effectively tune the control parameters. However, keep in mind that no “auto-tuning” function is built into the software. The best way to tune is through sustained trial and error methods.

The SuperFlow chassis dynamometer systems use digital Proportional, Integral, and Derivative (PID) control parameters to provide electrical control signals to the eddy current absorber or AC motor. Default parameters are provided with the system to handle the majority of vehicle applications. You may adjust these parameters as necessary to adapt to a specific application.

Contact SuperFlow Customer Service for assistance.

11.2 Control Modes

A control mode refers to the output signal the system is controlling to. This could be the position of a load control valve or throttle actuator, or it could be measured dynamometer speed or torque. Even calculated values such as engine power can be used as a control mode.

The System Configuration Editor defines control modes. Up to five control modes are available for each controller. Up to four controllers are currently supported by the system—two primary and two secondary. Only the primary controllers are closed-loop controlled. However, any two of the four controllers can be selected as primary. When activating both primary controllers simultaneously, each must be assigned a different control mode (e.g., both throttle and load cannot control to dynamometer speed at the same time).

Typical combinations are:

- Throttle controlling ***torque*** and Dyno (servo valve) controlling ***speed***
- Throttle controlling ***speed*** and Dyno (servo valve) controlling ***torque***

In control theory, the following terms are commonly used:

- **Set point:** The value of the desired control through a channel to, for example, engine speed
- **Feedback signal:** The actual measured value of that channel
- **Error:** The difference between the set point and the feedback signal

The two general types of control modes are **manual** and **servo**. The control system software was designed to provide seamless mode switching. This means it is possible to switch from manual to servo control mode or from one servo control mode to another while the engine is running. The system will automatically determine the set point of the new control mode during the transition to avoid abrupt changes in load or throttle position. This is a very effective way to troubleshoot a control mode problem versus a water (or eddy current) system problem.

11.2.1 Manual (Position) Control Mode

Also called “open loop” control mode, this mode only sends a position signal to the corresponding actuator (the load controller or the throttle controller). It does not take the feedback signal into consideration and thus has no self-correcting effect. The manual (position) control mode is used whenever the control signal is only determined as a “% of full range” of the controller actuator.

With the dynamometer load controller in the manual control mode, the load on the dynamometer is determined by the position of the load control valve (or the electric current in the dynamometer eddy current coils). The operator determines a “% of load” value which sets the valve (or current) to a particular percentage of its full operating range. The resulting load on the dynamometer is purely a function of water flow through the valve (or current through the coils) at that position, which combines with the rotational speed of the absorber to create a resisting torque. The valve position (or electric current) is not affected by any feedback signals.

The % of load setting does not correspond to any specific torque value but rather to a torque curve as a function of speed. In this mode the operator can easily stall the engine by applying excessive load.

The manual mode is typically used for diagnostic purposes or to warm up the engine (this is only practical if the appropriate position is approximately known by experience).

If a throttle control option is installed, when it is in the manual control mode, the system will control the engine throttle to a given percentage (%) of full travel. No actual throttle position feedback is provided; the percentage of full travel indicated by the control system corresponds to the value at the throttle actuator, not the actual throttle position of the engine. If the linkage between the throttle actuator and the throttle valve is not adjusted properly for end stops and travel (or if it is nonlinear), it causes a difference between actuator position and actual throttle position.

11.2.2 Servo Control Mode

Also called “closed loop” control mode, this mode sends a position signal to the corresponding actuator (the load controller or the throttle controller), measures the resulting change in the controlled variable, calculates the error, and refines the position signal until the desired set point is reached and maintained. The servo control mode is used whenever the control signal is tied to a measured variable.

Speed Control Mode

This is the most common dynamometer control mode used during automated tests. Speed control mode is an excellent example of a closed-loop control system because the feedback signal and the error signal influence the control output. The load control valve or eddy current is controlled by the system to maintain a desired dynamometer speed (the set point). The load position will be modulated so the load applied by the absorber matches the speed output of the dynamometer to the desired operating point.

Speed control is used in all automated tests that step through the engine rpm band while recording data. Speed control can also be used to maintain the vehicle at a constant speed while the throttle is varied. However, if the throttle is not opened sufficiently for the vehicle to reach the desired set point, load control will never activate. Only when the vehicle speed is at or above the set point will the load controller start to vary the load on the dynamometer to bring the feedback signal to the set point. This means a transition phase usually occurs where the set point is exceeded before the feedback signal settles to the desired value. This is called “overshoot” and is a normal phenomenon. The control parameters can be adjusted for faster or slower system response and more or less overshoot.

A throttle controller can also be used in speed control mode. The throttle is then modulated to reach the desired dynamometer speed independently of the dynamometer load applied. This test mode can be used to simulate cruise control operation.

Torque Control Mode

This is the most common throttle control mode used during automated tests. The throttle actuator is controlled by the system to maintain a specific dynamometer torque (the set point). The throttle position modulates so the torque produced by the engine matches the set point. This typically results in torque control to better than ±1 lb•ft (N-m) of the set point.

A typical application for a combination of throttle controlling torque and load controlling speed is the mapping of an engine. By stepping through the torque range for each speed point, the complete engine map can be covered in the shortest possible time.

WARNING: Always turn the dynamometer load control on (in speed mode) before you switch the throttle to torque mode. If no load is applied by the dynamometer, the throttle controller will immediately open the throttle fully in an attempt to achieve the desired torque. This will result in an immediate engine overspeed condition.

The load (servo valve) controller can also be used in torque control mode. The dynamometer load then modulates to reach the desired torque independently of the throttle position. This test mode is used to apply a constant torque to accessory belts or chain drives.

Other Control Modes

Additional control modes may have been defined for systems used in special applications. It is also possible for dyno operators to define their own control modes. Examples are:

- Horsepower
- Throttle position
- Manifold (boost) pressure
- Engine speed (for engine dynamometers)

11.3 Selective Control

When system power is switched on, it defaults to the manual control mode (also called position control mode). The operator can then select servo control mode for either controller in any available control mode.

In each control mode, it is possible to modify the control output signal using the handheld controller. The ranges for each control mode of the encoder can also be changed to suit the user's needs.

The handheld controls allow continuous adjustment of the set point. Three sensitivity selections are available for each control mode (fine, medium, coarse). The sensitivity selection determines how many button pushes (or turns of the encoder knob on a wireless handheld) are required for a given set point change. The selection from coarse to medium changes the encoder sensitivity by a factor of 2. A change from coarse to fine changes the controller sensitivity by a factor of 10.

Figure 11-1. Handheld Controller

Example:

If the total control output range is 0–100, then each click stop on the encoder will change the set point output as a function of sensitivity selection:

Table 11-1. Control Step Values

Control Mode	Range	Coarse	Medium	Fine
Manual	100%	10%	5%	1%
VehSpd	200 mph	10 mph	5 mph	1 mph
VehTrq	2500 lb•ft	100 lb•ft	50 lb•ftt	10 lb•ft

11.4 PID Control Setup

The WinDyn control system requires operator interaction in two separate portions of the software. First you must assign and define the desired control channels in the WinDyn Configuration file (CFA). Then tune PID using the operator control console or handheld interface.

Current hardware limits the number of closed-loop control outputs to two controllers. Each controller is given a name in the configuration file. Typically, names such as Load, Servo, Dyno, or Throttle are used. However, you can change the name through the WinDyn Configuration file (CFA). Typically, if Load or Servo is selected, the dynamometer load will control vehicle speed or torque. If Throttle is selected, the engine throttle controls vehicle speed or torque. However, the naming of the controller in the software is arbitrary, so misnaming is very possible.

Each controller can be assigned up to five control channels. Any measured or calculated channel may be assigned as a control channel through the Configuration file (CFA). Typically, on chassis dynamometers, dyno speed in mph and a calculated wheel torque is used. On an engine dyno, engine speed in rpm and measured engine torque is used. After assigning a channel, you must allocate minimum and maximum values to the channel to enable the control outputs.

11.5 Control Mode Parameters

SuperFlow systems utilize a Proportional, Integral, and Derivative (PID) gain method, hence the term PID control. SuperFlow provides each system with an initial set of optimized control mode parameters to provide adequate control for a wide variety of testing applications. The parameters are:

- Actuator phase
- Controller phase
- Open rate
- Close rate
- P-Gain
- I-Gain
- I-Threshold
- I-Time
- D-Gain
- D-Time
- Filter
- Delay

11.5.1 Actuator Phase

The actuator phase (allowed values: 0 or 1) determines the actuator direction of travel as a response to the controller output signal. A "1" inverts the signal. If the actuator phase is 0, the actuator goes from 0 to 100% when the controller output signal goes from 0 to 100%. If the actuator phase is 1, the actuator goes from 100 to 0% when the controller output signal goes from 0 to 100%. The actuator phase must be correctly selected to properly drive the control mechanism on the dyno system.

Table 11-2. Actuator Phase

Actuator Type	Actuator Phase	0%	100%
Throttle	0	Idle	WOT
Eddy current	0	No load	Full load
Control valve on water brake outlet	1	No load	Full load
Control valve on water brake inlet	0	No load	Full load

Examples

- **Throttle Control with Electric Actuator**

  If the actuator phase is 0, and the manual throttle position control is varied from 0 to 100% on the controller, the throttle actuator will move the throttle from fully closed (idle) to fully opened (WOT) position.

  If the actuator phase is 1, and the manual throttle position control is varied from 0 to 100% on the controller, the throttle actuator will move the throttle from fully opened (WOT) to fully closed (idle) position.

  The throttle controller typically requires an actuator phase of 0.

  In some situations, such as when the throttle actuator is mounted on the reverse side of the throttle lever, the actuator phase will be 1. Take care in these situations because the throttle actuator will be at its 100% position for engine idle. When power is turned off, the throttle actuator will return to its 0% position, or WOT, on the engine.

- **Eddy Current Dynamometer Load Control**

  If the actuator phase is 0, and the manual load control is varied from 0 to 100% on the controller, the coil excitation current will increase from 0 to 100% and the dynamometer load will increase from zero load to full load.

  If the actuator phase is 1, and the manual load control is varied from 0 to 100% on the controller, the coil excitation current will decrease from 100 to 0% and the dynamometer load will decrease from full load to zero load.

  Eddy current dynamometer load controllers typically require an actuator phase of 0.

- **SuperFlow Water Brake Load Control**

  The SuperFlow water brake is an outlet-controlled device. If the actuator phase is 0 and the manual load control is varied from 0 to 100% on the controller, the servo valve position will change from 100% (fully closed) to 0% (fully open), and the dynamometer load will decrease from full load to no load.

  If the actuator phase is 1, and the manual load control is varied from 0 to 100% on the controller, the servo valve position will change from 0% (fully open) to 100% (fully closed), and the dynamometer load will increase from no load to full load.

  Water brake dynamometers with the load controller on the outlet typically require an actuator phase of 1. The phase will be 0 when the load controller is on the inlet.

11.5.2 Controller Phase

The controller phase (allowed values: 0 or 1) determines closed-loop control polarity, i.e., the direction of movement of the controller output as a response to a change in the feedback signal (the controlled parameter). If the controller phase is 1, when the feedback signal increases, the controller output signal will increase. If the controller phase is 0, when the feedback signal increases the controller output signal will decrease.

NOTE: *The actuator phase must be properly determined before the controller phase is set because the actuator phase also has an impact on the aggregate polarity of the closed-loop control system.*

Example 1:

A typical throttle actuator controlling to ***engine speed*** (with **actuator** phase = 0):

If the **controller** phase is 1 and measured engine speed increases, the controller output will increase, and the throttle actuator will open the throttle more, allowing the speed to increase further still.

If the **controller** phase is 0 and measured engine speed increases, the controller output will decrease, and the throttle actuator will close the throttle more, maintaining the desired engine speed.

In this application, the **controller** phase should be **0**.

Example 2:

A typical throttle actuator controlling to ***engine torque*** (with **actuator** phase = 0):

If the **controller** phase is 1 and measured engine torque increases, the controller output will increase, and the throttle actuator will open the throttle more, allowing the torque to increase further still.

If the **controller** phase is 0 and measured engine torque increases, the controller output will decrease, and the throttle actuator will close the throttle more, maintaining the desired torque.

In this application, the **controller** phase should be **0**.

Example 3:

An Eddy current dynamometer controlling ***engine speed*** (with **actuator** phase = 0):

If the **controller** phase is 1 and measured engine speed increases, the controller output will increase, and the load will increase, maintaining the desired speed.

If the **controller** phase is 0 and measured engine speed increases, the controller output will decrease, and the load will decrease, allowing the speed to increase even more.

In this application, the **controller** phase should be **1**.

Example 4:

An Eddy current dynamometer controlling ***engine torque*** (with **actuator** phase = 0):

If the **controller** phase is 1 and measured engine or roll torque increases, the controller output will increase, and the load will increase, allowing the torque to increase even more.

If the **controller** phase is 0 and measured engine or roll torque increases, the controller output will decrease, and the load will decrease, maintaining the desired torque.

In this application, the **controller** phase should be **0**.

Example 5:

A SuperFlow water brake controlling to ***engine speed*** (with **actuator** phase = 1):

If the **controller** phase is 1 and measured engine speed increases, the controller output will increase, and the load will increase, maintaining the desired speed.

If the **controller** phase is 0 and measured engine speed increases, the controller output will decrease, and the load will decrease, allowing the speed to increase even more.

In this application, the **controller** phase should be **1**.

Example 6:

A SuperFlow water brake controlling to engine torque (with **actuator** phase = 1):

If the **controller** phase is 1 and measured engine torque increases, the controller output will increase, and the load will increase, allowing the torque to increase even more.

If the **controller** phase is 0 and measured engine torque increases, the controller output will decrease, and the load will decrease, maintaining the desired torque.

In this application, the **controller** phase should be **0**.

Table 11-3. Controller Phase

Control Device	Actuator Phase	Control Channel	Controller Phase
Throttle	0	Engine Speed	0
	0	Engine Torque	0
Eddy Current	0	Engine or Roll Speed	1
	0	Engine or Roll Torque	0
Servo Valve	1	Engine Speed	1
	1	Engine Torque	0

11.5.3 Open and Close Rate

Allowed Values: 0–7

These parameters apply a filter to the control system output signal to the control mechanism. Suggested values: 0 (they are not generally used on anything except diesel engine dynos)

What it Does

The Open and Close Rate parameters provide the capability to control the valve open-versus-close rate to compensate for a controller that acts differently while opening versus closing (unloading versus loading). Because nearly all SuperFlow systems have these parameters set to zero, this feature is not currently used.

11.5.4 P-Gain

$P_{term} = (Error * P_{gain\_value} * Phase)$ ***where Phase = ±1***

Allowed values: Any floating point value

Suggested Value Range

- 0.4 to 2 for engine dynos controlling to engine speed
- 350 to 450 for CycleDyn controlling to vehicle speed
- 500 to 600 for AutoDyn controlling to vehicle speed

What it Does

Proportional Gain determines how rapidly error influences the control to the dyno or to the throttle. The P-Gain is proportional to the difference between the desired set point valve and the actual current value. Its effect is greatest when the actual reading is far away from the set point. If the P-Gain is too high, the system could overshoot the set point. The system shows instability by oscillating (alternately overshooting and undershooting the set point) or surging. The oscillation (or surging) may slowly subside over time. If the P-Gain is too low, the system will never be within the range where the I-Gain will start working (I-Gain threshold). Consequently, the set point is never reached. When setting up the control system, it is better to start on the low side (enter smaller gain numbers) and then increase the values slowly.

Suggested Adjustment Technique

First adjust the P-Gain parameter. When initially adjusting the P-Gain, SuperFlow recommends setting all other parameters to 0. With the I-Gain at zero, the system will never reach its set point, but the control channel (engine speed, throttle, vehicle speed, etc.) will move toward the set point. The purpose of adjusting the P-Gain with the other parameters at zero is to adjust the P-Gain so the system reacts reasonably quickly without exhibiting instability. Observe the (engine or wheel) speed and the control valve position indicator (where available) while the system is seeking the set point. Note how quickly the controller responds and whether it overshoots and undershoots as it seeks to control to the set point.

The control system will not pull the engine (or wheel speed) all the way down to the selected speed because the I-Gain and I-Threshold are not set up yet. On an engine dynamometer, the engine speed may stabilize at 300 to 500 rpm above the set point.

Try a minimal value of P-Gain. Successively double it until step response improves. If you notice high frequency (1-10 Hz) steady-state instability as a result of increasing P-Gain, use half the current value of P-Gain. Since P-Gain may have other undesired effects on step response, use the minimal amount necessary to improve step response.

Check for stability at a minimum of four different speed set points. If the system surges for 30 seconds or less and then settles down, that’s okay. This is corrected when D-Gain is adjusted.

11.5.5 I-Gain

I_{term} = (Error * I_{gain_value})
Allowed values: any floating point value

Suggested Value Range

- 0.01 to 0.08 for engine dynos
- 0.01 to 1 for CycleDyn controlling to vehicle speed
- 0 to 2 for AutoDyn controlling to vehicle speed
- Suggested setup prior to adjustment: 0.01

What it Does

The purpose of the integrator is to integrate the error to zero. The I-Gain (Integrator Gain) keeps increasing controller output until the desired set point is reached. It sets the gain applied to the integrated error and controls how fast the system responds to set point changes. This process is much like the operator of a manual dyno who observes the current speed and keeps adding load, a little at a time, until the set point is reached. It helps minimize time-average deadband errors. If the I-Gain is too low, the engine or vehicle speed will take a long time to achieve its set point. If the I-Gain is too high, the system may overshoot excessively and take a long time to settle down or may never stabilize at the set point.

Suggested Adjustment Technique

Start with the minimal suggested value of I-Gain. Increase I-Gain by successively doubling it until the rise time of the closed-loop step response of speed or torque is approximately 1 to 3 seconds. Since the I-term is an integrated value, integrator wind-up can occur if the I-term is "turned on" over too wide a bandwidth. The I-Threshold parameter is used to adjust this bandwidth and prevent the integration from creating too much gain due to a large error signal. The I-Time parameter allows the system to integrate the error signal over a longer period of time to create a smoother gain signal. You could use this parameter to force the system to smooth through a random, erratic change in the error signal.

Usually it is easiest to start the PID adjustment with the integrator turned off (value = 0). After refining the P- and D-Term, the system should respond properly and stabilize properly. However, it may not actually reach the desired set point.

11.5.6 I-Threshold

Allowed values: Any floating point value

This value is associated with the control channel, i.e., rpm or mph.

Determines bandwidth for integration of the error signal.

Suggested Value Range

- At least large enough to capture the control channel offset due to the P-Term for engine dynos (usually around 1000 rpm or less)
- At least large enough to capture the control channel offset due to the P-Term for chassis dynos controlling to vehicle speed (usually 5-10 mph)
- Suggested setup prior to adjustment: must be some value other than zero, as a zero will turn off the integrator completely.

What it Does

The I-Threshold parameter specifies the range from the set point where the I-Gain will function. For example, with an I-Threshold of 300 rpm and a set point of 1500 rpm, the I-Gain would be active from 1200 to 1800 rpm (the magnitude of the error must be 300). Further, if the P-Gain does not bring the speed within this range, the I-Gain will not become active and the speed will never reach the set point. In other words, the Integrator Threshold determines the window within which the Integrator takes effect. This means the I-Term will only become operational when the actual value enters a window of "set point ± I-Threshold."

The integrator should take effect when the P-term and the D-term lower the error term as much as possible. This is very useful for limiting the integrator output while the control system is in a major transitional phase, i.e., a transition from no load to the first set point. Furthermore, if the I-Threshold were set to zero, then in essence, the integrator would always be turned off.

The integrator term tends to slow down the system response by stabilizing the control algorithm as the set point approaches. On systems with lots of system inertia (slower response) such as a chassis dynamometer, the integrator should only become active when the control channel value is relatively close to the desired set point.

Suggested Adjustment Technique

To set the I-Threshold, observe the difference between set point and engine/vehicle speed during the above P-Gain adjustment. Double this rpm (or mph) value and enter it as the I-Threshold. This is not a critical adjustment; if this number is too small, all that happens is the engine does not load down the final portion of the way to the desired rpm, and the system will never reach its set point.

11.5.7 I-Time

Allowed Values: 0–256

Determines the number of control system cyclic loops to use to determine the I-Term.

Suggested Value Range

Typically a 0 or low value (less than 10) for all system types.

Increasing the value will cause the I-Term to delay its effect.

Suggested Setup Prior to Adjustment: 0

What it Does

The I-Time parameter determines the time base within which the error integrates. It is used to define the rate in which the integrator is processed. This time determines how often the integrator is operated during the controller update. For example, a setting of 5 would cause the integrator to be updated every 5th time. This parameter is used to slow down the integrator. The wider this time base, the slower the system response will be, making the system more stable but also increasing overcompensation of the error. On systems with lots of system inertia (= slower response) such as chassis dynamometer, the integrator should work within a fairly narrow time band.

11.5.8 D-Gain

$D_{term} = ((Error_{Current} - Error_{A\_While\_Ago}) * D_{gain\_value})$

Allowed values: Any floating point value

Suggested Value Range

- 4 to 20 for engine dynos controlling to engine speed
- 0.025 to 5000 for a CycleDyn controlling to vehicle speed
- 0 to 5000 for an AutoDyn controlling to vehicle speed

Suggested Setup Prior to Adjustment

- Engine Dyno controlling to engine speed D-Gain = 1
- Chassis Dyno controlling vehicle speed D-Gain = 5000
- Chassis Dyno controlling roll torque D-Gain = 0.01

What it Does

The D-Gain helps stabilize the control channel to the set point. It helps reduce the ringing, oscillations and instability associated with high P-Gain and high I-Gain. The D-Gain is proportional to the rate of change of the engine rpm or wheel speed. The D-Gain determines to what extent error rate of change influences control to the dyno or to the throttle. If the D-Gain is too low, the control system will have excessive overshoot and will surge for a long time before settling down. If D-Gain is too high, the system will take too long to reach the set point and may be oversensitive to changing speed, thus making the system unstable.

Suggested Adjustment Technique

Use the minimum D-Gain possible to reach an acceptable reduction in ringing. Gradually increase D-gain to damp oscillations and reduce overshoot. With a smaller I-Gain, the overshoot of the set point will be minimal and can possibly can be eliminated. To check the D-Gain adjustment, set the engine speed to midrange, then set the engine speed 100 rpm higher (or set the wheel speed 5 mph higher). Check for surging, overshoot, and ringing at the control valve position indicator (for a water brake).

11.5.9 D-Time

Allowed Values: 0-256

Determines the number of control system cyclic loops to use to determine the D-Term (effectively creates a cumulative error based on control system cyclic time).

Suggested Value Range

Typically a 0 or low value (less than 10) for all system types.

Increasing the value will cause the D-Term to delay its effect.

Suggested Setup Prior to Adjustment: 0

What it Does

The D-Time parameter is used to control the size of the window over which the derivative is measured. Since increasing or decreasing the window size also adjusts the resolution and scale of the measurement, the D-Time cannot be adjusted without also affecting the D-Gain.

11.5.10 Filter

Allowed values: 0–7

Suggested Value Range: Usually set to zero

What it Does

This term is the filter rate applied to the feedback signal. If the feedback signal in the control loop is noisy, set this value fairly high. However, the filter adds delay to the feedback, so it will slow down the system response. The filter algorithm is the same as those used for the Open and Close rate parameters. The larger the number, the more filtering and delay.

Suggested Adjustment Technique

Leave the filter at zero unless a noise problem is apparent and cannot be corrected. In that case, start with the lowest filter value for that channel and gradually increase the filter until the problem does not affect control stability. The step response performance may be affected.

11.5.11 Delay

Allowed Values: Any integer value

Suggested Value Range: Usually set to zero

What it Does

This term applies a delay to the controller output signal. It provides a method in which a delay can be introduced between the control system and the actual output of the control valve. In essence, this parameter indicates the number of passes (cycles) that will occur through the control system before the controller output signal will be updated.

Suggested Adjustment Technique

Leave the delay at zero for most applications. If you want to delay controller response to smooth through sudden changes in the device under control, then increase the delay value until the control system responds smoothly.

11.6 Adjusting Control Mode Parameters

It is useful to set up two speed set points or two torque set points that the operator may manually toggle between to observe closed-loop system step response for the purpose of tuning the control parameters. Determine these set points to prevent the engine from reaching excessive speed and to ensure the engine throttle remains above idle.

It is helpful to create a strip chart display object on a WinDyn screen to allow real-time observation of the control system while performing adjustments. WinDyn uses the channels named SETPT1 and SETPT2 as its control channels. By displaying either of these channels and the desired control channel on a strip chart at the same time, you can observe control system response in real time.

It is best to tune by individually adjusting the control parameters in each of the control loop modes. If you encounter a problem while running dual-mode, closed-loop control, the easiest approach is to go back and individually tune each of the two single-mode control loops that would otherwise be operating simultaneously.

For best results, in engine dynamometer applications, SuperFlow recommends using the load controller to control the engine rpm. The engine controller (throttle) can be used in throttle position (manual mode) or to control the engine torque (close-loop mode). In chassis dynamometer applications, SuperFlow recommends using the absorber unit to control the vehicle speed.

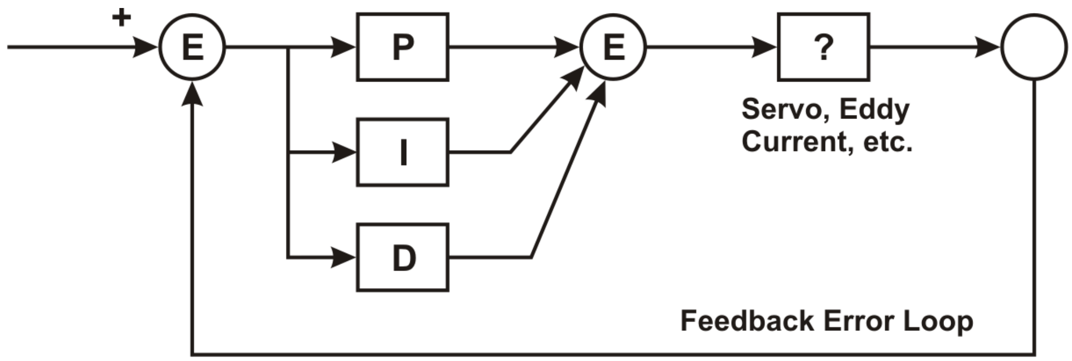

Figure 11-2. Closed-Loop Control

The SuperFlow control system functions shown in Figure 11-3 produces a cumulative gain (P+I+D) to the control mechanism based on the error signal feedback. The control systems cycle at a 400-hz (2.5-ms) rate.

This PID adjustment procedure assumes the test system and engine/vehicle are operating properly and that the electrical or hydraulic supply to the test system is sufficient.

On the SuperFlow water brake it is necessary to determine whether the boost valve will be used and the position of the capacity valve before making any adjustments on the control parameters.

Parameters not listed in this section are best left at the original value or zero.

Preliminary Steps

1. Turn off the I-Gain and the D-Gain by setting them to zero.
2. Start with a P-Gain term at the lower end of the suggested value range for your system.

Begin Adjustment

1. Successively double P-Gain until you reach satisfactory step response. If the P-Gain results in continuous high-frequency, steady-state instability, lower it by half again.
2. Gradually increase P-Gain until instability reappears, then lower it by 20%.
3. Start with a D-Gain term at the lower end of the suggested value range for your system. Gradually increase D-Gain (in small increments) until the overshoot is acceptable and steady-state stability is good.
4. Note the difference between the set point and the actual value. Add 50% to this difference. Set the I-threshold at this calculated number.
5. Start with an I-Gain term at the lower end of the suggested value range for your system. Successively double I-Gain until the system settles onto the set point within 3–5 seconds. If instability occurs, lower I-Gain by half again.
6. Gradually increase I-Gain until instability reappears, then lower it by 20%.
7. Continue adjustment until satisfied. You may need to alter the other parameters (I-Time, D-Time, Filter, Delay, etc.) to achieve reach exact response desired.

Figure 11-3 illustrates the influence of various parameters on the system response. The (exaggerated) example shows the effect of entering a new set point (of 2500 rpm) for engine speed on the actual system response.

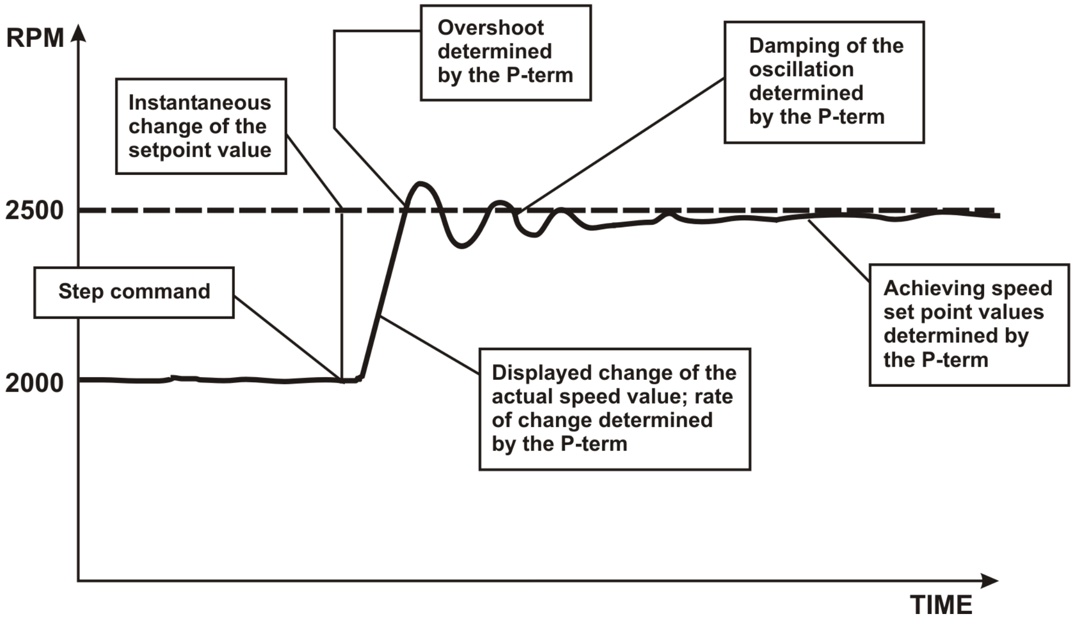

Figure 11-3. System Response Parameters

11.7 WinDyn Control File

The control parameter information is stored in a file with a *.CCP file name. When a CCP file is saved from the handheld controller or console it is always saved to a file with the same name as the currently installed configuration file but with a CCP extension. The existing file is overwritten without warning.

To save a CCP file to a different or new file name, from the WinDyn main menu, select **System>>Save>> Control Parameters**. A dialog box appears where you can select or enter the name of the file to save the current control parameters to.

You may load control parameters using the WinDyn Test Group function if the file is designated when designing the test group.

20

Service and Calibration

20. Service and Calibration

20.1. Inspection and Maintenance Instructions

The AutoDyn should be periodically serviced according to the inspection and maintenance schedule below. Depending on your location, maintenance contracts may be available from SuperFlow. Contact your Service representative for details.

Record reference information for your system below.

Date of delivery:		
Date of installation / training by SuperFlow:		By:
Date of first use:		

The following table allows you to keep track of monthly and 3-monthly service.

Please fill this out with the date of the service, the type of service (monthly or 3-monthly), and the name of the technician who performed the service. A check-sheet for monthly and 3-monthly maintenance is included for your records. Copy this original for each scheduled maintenance.

AutoDyn Maintenance chart

Component	Inspection interval	What to do…	Replace when/if…	SuperFlow Part Number
Handheld controller cable	each use	Inspect for wear, damage	worn or damaged	1200A-1867
Pressure fittings	each use	Inspect for wear, damage	worn or damaged	3500P-20210204
Pressure hoses	each use	Inspect for wear, damage	worn or damaged	3600P-641180
Tie-down straps	each use	Inspect for wear, damage	worn or damaged	-
All electrical cables and sensor cables	each use	Inspect for wear, damage	worn or damaged	-
Sensor box wheels	every 1 month	Clean out debris and dust	wheel is stuck	3430P-0014
Drive-shaft joints and spline	every 1 month	1 pump with hand grease gun (see note 1)	excessive play	3900Z-14801 (10in) 3900Z-15501 (13in)
Drive-shaft bolts	every 1 month	Tighten to…20-24 ft-lb (27-32 Nm)	stripped or damaged	3/8-24 UNF
Restraint bar fasteners	every 1 month	Tighten to…80-90 ft-lb (110-120 Nm)	stripped or damaged	
Roll torque sensor (load cell)	every 3 months	Calibrate the sensor	cannot be calibrated	1200A-2342
Load cell bolts	every 3 months	Tighten to… 300 ft-lb (400 Nm)	stripped or damaged	9-47-2.50-10G
Load cell bracket screws	every 3 months	Tighten to… 35 ft-lb (47 Nm)	stripped or damaged	9-37-1.00-10G
Brake shoes	every 3 months	Check for wear	thickness < 0.06" (1.5 mm) if even wear	2300Z-0506
Roll speed magnetic pick-up	every 3 months	Check for clearance, adjust to .005" (0.13 mm) at tightest point	damaged	1200A-2141
Air hose to brakes	every 3 months	Inspect for leaks, damage	leaking or damaged	3600P-1510
Air bags for brakes	every 3 months	Inspect for leaks, damage	leaking or damaged	4300P-6535
Air solenoid for brakes	every 3 months	Lubricate with a few drops of oil in the inlet	leaking or damaged	1200A-2343
Roll-to-axle bolts	every 3 months	Remove protective cover and tighten to…425 ft-lb (575 Nm)	stripped or damaged	Meritor part
Differential cooler hoses	every 3 months	Inspect for leaks, damage	leaking or damaged	
Differential cooler oil filter	every 3 months	Clean filter	damaged	Oberg part
Differential trunnion bearings	every 3 months	2 pumps with hand grease gun (see note 1)		3100P-0130
Inertia Roll pillow block bearings	every 3 months	2 pumps with hand grease gun (see note 1)	noisy or rough running	3100P-2203
EC absorber bearings	every 3 months	Grease until grease appears at overflow (see note 3)	noisy or rough running	-
Water brake absorber oil	every 3 months	check level - fill to centerline		Mobil 1 oil
Water brake absorber water filter	every 3 months	Replace (see note 4)	clogged or corroded	4500P-5060
Water brake absorber servo valve	every 3 months	Inspect for damage, clogging	damaged	1200A-0839
Water brake supply and drain hoses	every 3 months	Inspect for leaks, damage	leaking or damaged	-
Rollset cover plate or platform fasteners	every 3 months	Tighten	stripped or damaged	
Axle and differential	every 1 year	Maintain per Rockwell / Meritor instructions. Change oil (see note 2). Check for leaks.	-	1700P-8279 (EC) 1700P-8390 (WB)
Water brake absorber oil	every 1 year	Replace (approximately 8 fl.oz. or 240 cc - fill to centerline)	-	Mobil 1 oil
Dynamometer pit	every 1 year	Clean out debris and wash down	-	-
Dynamometer position	every 1 year	Adjust leveling bolts as necessary to level and secure dynamometer	-	

Note 1: use Lithium II high temperature water repellent automotive chassis grease. Slowly rotate rolls while greasing.
Note 2: use 4.5 gallons (16.9 liters) of GL5, SAE 80W/140 hypoid gear oil
Note 3: use grease (approved by the absorber manufacturer) to maintain original warranty.
Note 4: inspect and clean the water filter daily in the first week of use to remove all initial dirt and debris from the water system and plumbing

Monthly maintenance check sheet

Component	What to do…	Replace when/if…	OK	Notes
Sensor box wheels	Clean out debris and dust	wheel is stuck		
Drive-shaft joints and spline	1 pump with hand grease gun (see note 1)	excessive play		
Drive-shaft bolts	Tighten to…20-24 ft-lb (27-32 Nm)	stripped or damaged		
Restraint bar fasteners	Tighten to…80-90 ft-lb (110-120 Nm)	stripped or damaged		

Date:	Technician:

Note 1: use Lithium II high temperature water repellent automotive chassis grease. Slowly rotate rolls while greasing.

Note 2: use 4.5 gallons (16.9 liters) of GL5, SAE 80W/140 hypoid gear oil

Note 3: use grease (approved by the absorber manufacturer) to maintain original warranty.

Note 4: inspect and clean the water filter daily in the first week of use to remove all initial dirt and debris from the water system and plumbing

3-Monthly maintenance check sheet

Component	What to do…	Replace when/if…	OK	Notes
Roll torque sensor (load cell)	Calibrate the sensor	cannot be calibrated		
Load cell bolts	Tighten to… 300 ft-lb (400 Nm)	stripped or damaged		
Load cell bracket screws	Tighten to… 35 ft-lb (47 Nm)	stripped or damaged		
Brake shoes	Check for wear	thickness < 0.06" (1.5 mm) if even wear		
Roll speed magnetic pick-up	Check for clearance, adjust to .005" (0.13 mm) at tightest point	damaged		
Air hose to brakes	Inspect for leaks, damage	leaking or damaged		
Air bags for brakes	Inspect for leaks, damage	leaking or damaged		
Air solenoid for brakes	Lubricate with a few drops of oil in the inlet	leaking or damaged		
Axle and differential	Maintain per Rockwell / Meritor instructions. Change oil (see note 2). Check for leaks.	-		
Roll-to-axle bolts	Remove protective cover and tighten to…425 ft-lb (575 Nm)	stripped or damaged		
Differential cooler hoses	Inspect for leaks, damage	leaking or damaged		
Differential cooler oil filter	Clean filter	damaged		
Differential trunnion bearings	2 pumps with hand grease gun (see note 1)			
Inertia Roll pillow block bearings	2 pumps with hand grease gun (see note 1)	noisy or rough running		
EC absorber bearings	Grease until grease appears at overflow (see note 3)	noisy or rough running		
Water brake absorber oil	check level - fill to centerline			
Water brake absorber water filter	Replace (see note 4)	clogged or corroded		
Water brake absorber servo valve	Inspect for damage, clogging	damaged		
Water brake supply and drain hoses	Inspect for leaks, damage	leaking or damaged		

Date:	Technician:

Note 1: use Lithium II high temperature water repellent automotive chassis grease. Slowly rotate rolls while greasing.

Note 2: use 4.5 gallons (16.9 liters) of GL5, SAE 80W/140 hypoid gear oil

Note 3: use grease (approved by the absorber manufacturer) to maintain original warranty.

Note 4: inspect and clean the water filter daily in the first week of use to remove all initial dirt and debris from the water system and plumbing

20.2. Maintenance record

Date:	(example)				
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Technician:	John Doe				

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* **NOTE** Roll bearings and absorber bearings which are subject to dusty or high moisture environments should be maintained according to the more stringent schedule outlined below.

The rollset bearings are prelubricated with grease, but must be periodically relubricated. The manufacturer's recommendation is based on environmental conditions. The bearing operational temperature is from -20°F to +275°F. SuperFlow has observed normal operating temperatures of 130°F. The required relubrication cycle is dependent upon the operating conditions, speed, temperature, dust, moisture, and other environmental conditions. The following lubrication guide must be followed to prevent catastrophic bearing failures:

Conditions	**Minimum Relubrication Interval**
Normal	Every 100 hours of operation or 3 months, whichever occurs first
Dusty Environment	Every 50 hours of operation or 1 ½ months, whichever occurs first
High Moisture Environment	Every 50 hours of operation or 1 ½ months, whichever occurs first

Grease should be added slowly while the shaft is rotated, until a slight bead of grease forms at the seals. In harsh environments, relubrication should be as often as necessary to maintain a slight grease leakage at the seals. Use a lithium base grease, or a grease recommended by a reputable grease manufacturer as being suitable for ball bearings and compatible with lithium base grease.

20.3. Calibration instructions

The sensors used on the AutoDyn should be periodically calibrated for highest measurement accuracy.

* **NOTE** Technical specifications of all sensors can be found in the datasheets included in the "Accessories and options" section of this manual.

* **NOTE** To avoid accidental miscalibration, a safeguard has been built into the calibration editor. Calibration entries which exceed +/- 10% change from the original calibration value will be rejected. If, for any reason, the real error exceeds this 10% and the calibration must be adjusted by a greater value, you will have to modify the configuration file first, using the DEF Configuration Editor. Final calibration can then be performed following the methods described below. Of course, apparent calibration drifts of more than 10% should be investigated as they may point to a defective sensor or a problem with the electronics.

20.3.1. Torque sensor (load cell) (channel 2)

* **NOTE** This sensor is only present in upgradeable AutoDyn systems using the axle and differential.

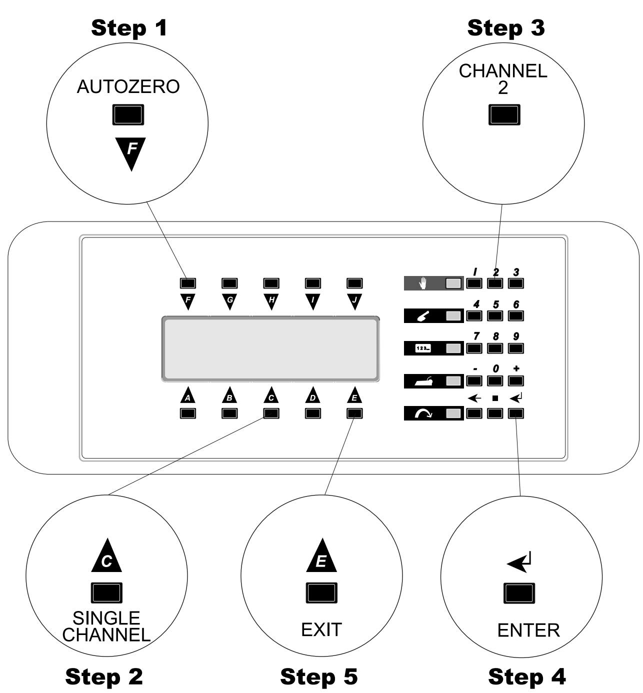
The torque link measures the force created from the absorber load and from parasitic losses in the axle and sends an analog voltage to the CPU for conversion and measurement. The force measured is only as accurate as the calibration that is performed on the unit. If the calibration is off by five percent, then the measured power will be off by five percent as well. The load cell has been pre-calibrated at the factory, but it is wise to check the calibration periodically. SuperFlow recommends doing this every month.

To calibrate the load cell, perform the following steps:

1. The test system and test room should be at normal operating temperature. Leave the test system power on for at least 15 minutes prior to performing a torque calibration.
2. Hang the calibration arm on the load cell. Make sure there is no weight on the calibration arm at this time.
3. Zero the Roll Torque Channel from the handheld controller or from WinDyn:

From the handheld controller:

Select “**Autozero**” (F-key) followed by “**Single channel**” (C-key) Select channel #2 (RolTrq) by pressing **“Select”** followed by “**2**” and **“Enter”**. Press **“Exit”** (E-key) to return to the main menu.



From Windyn:

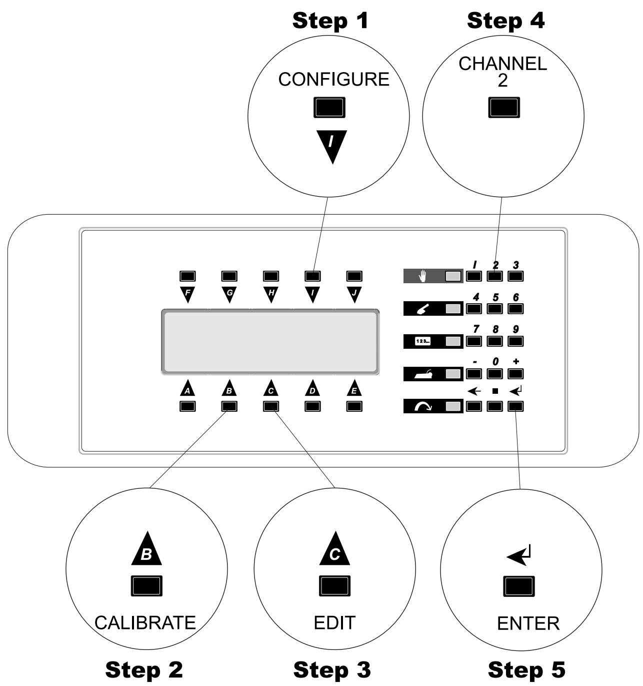
Select “**Calibrate|Channels**” from the main menu. A calibration dialog box appears. Scroll down the list until channel #2 (RolTrq) appears and select it. Click on “**Zero**” and “**OK**”.

4. Put the five 20 lb (9.1 kg) weights that come with the dyno on the end of the 5-foot (1.524 m) long calibration arm. The applied torque is then: 5.00 ft x 100 lbs = 500 lb.-ft (5 x 9.1 kg x 9.81 x 680 m = 244.9 Nm). Wait a few seconds for the arm to stabilize.
5. Enter the correct calibration of 500 lb.-ft (680 Nm) for the current torque on the handheld or from WinDyn:

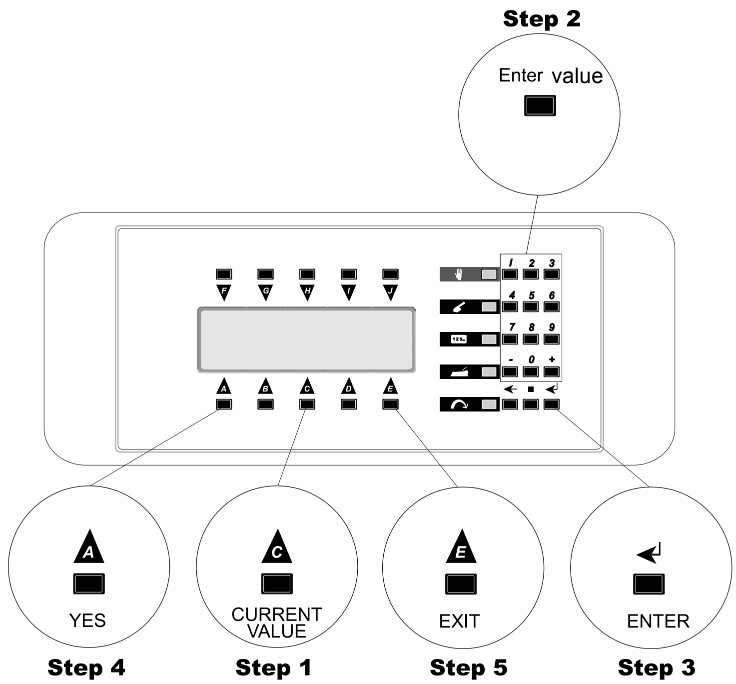
From the handheld controller:

Select “**Configure**” (I-key) followed by “**Calibrate**” (B-key)

Select channel #2 (RolTrq) by pressing “**Edit**” (C-key), then “**Select**” followed by “**2**” and **“Enter”**.



Choose “**Current value**” (C-key) and enter 500 lb.-ft (680 Nm). Verify that your entry is correct and confirm by pressing “**Yes**” (A-key). Press the “**Exit**” (E-key) twice.
A message will appear, asking to save the changes in the calibration file on the harddisk of the computer. Do NOT save the changes at this time, by pressing “**No**” (E-key).
Exit the Configuration mode by pressing “**Exit**” (E-key).



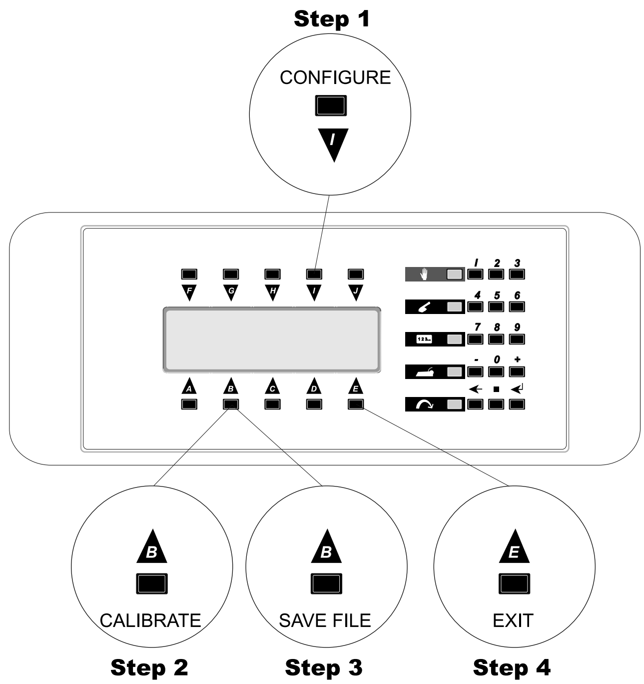
From Windyn:

Click on “**Calibrate**”, enter the new value of 500 lb.-ft (680 Nm) and click “**OK**” followed by “**Done**”

6. The calibrated value should appear on the handheld and Windyn displays. If this is not so, there may be something binding or broken in the eddy current absorber or the load cell. Contact SuperFlow Customer Service for assistance.
7. Remove the calibration weights one at a time, let the reading stabilize each time, and check for linearity. Linearity should be better than +/- 5 lb.-ft (7 Nm) of torque.
8. Remove the calibration arm from the absorber.
9. Perform an Autozero of Channel 2
10. Save the new calibration as follows:

From the handheld controller:

Select “**Configure**” (I-key) followed by “**Calibrate**” (B-key). Press “**Save file**” (B-key). Press the “**Exit**” (E-key) twice to return to the main menu.



From Windyn:

Select “**Test Group**” and “**Receive|Calibration**” from the main menu. The calibration data will be saved in the default file to avoid calibration errors.
A message will appear to confirm that the file saving operation completed succesfully. Click on “**OK**”.

20.3.2. Barometric pressure sensor (channel 76)

The barometric pressure sensor is installed on the printed circuit board (PCB) inside the sensor box.

1. Obtain an accurate, uncorrected barometric pressure reading in InHg (for US units systems) or in kPa (for metric units systems) from a mercury barometer. If you have no mercury barometer, contact a local airport or weather service and ask for the “station pressure”.

2. Calibrate the sensor using the handheld controller or using WinDyn:

2.1. Using the handheld controller:
Select Configure (I), then Calibrate (B), then Edit (C).
Select channel 76
Select Current Value (C)
Enter the correct value obtained in 1. above and press Enter (↵)
Verify that your entry was correct and, if so, press Yes (A)
Select Exit (E) and again Exit (E)
If a PC is connected, answer Yes (D) to the Save changes… question.
Select Exit (E) to return to the start menu

2.2. Using WinDyn:
Select Calibrate channels from the main menu
Select channel 76
Select Calibrate
Enter the correct value obtained in 1. above and press OK
Select Done

20.3.3. Pressure transducers (channels 61~70)

Pressure transducers use the calibration provided by the transducer manufacturer. This calibration is already programmed in the DEF Configuration Editor program. This will provide an accuracy of better than 1% of full scale. If you have pressure sources and calibrated pressure measurement equipment with a higher accuracy, it is possible to calibrate the pressure sensors as follows:

1. Verify that no actual or residual pressure is being applied to the sensor which you want to calibrate. Zero the pressure transducer using the handheld controller or using WinDyn:

1.1. Using the handheld controller:
Select **Autozero** (F), then **Single Channel** (C).
Select the pressure channel to **zero**.
Select **Exit** (E).

1.2. Using WinDyn:
Select **Calibrate channels** from the main menu.
Select the pressure channel to zero.
Select **Zero.**
Select **Done.**

2. Apply a pressure to the pressure sensor using a controlled (constant) pressure source
3. Measure this pressure with your calibration equipment
4. Calibrate the sensor using the handheld controller or using WinDyn:

4.1. Using the handheld controller:
Select **Configure** (I), then **Calibrate** (B), then **Edit** (C).
Select the pressure channel to which the pressure is being applied.
Select **Current Value** (C).
Enter the correct value obtained in 2. above and press Enter (↵).
Verify that your entry was correct and, if so, press **Yes** (A).
Select **Exit** (E) and again **Exit** (E).
If a PC is connected, answer **Yes** (D) to the Save changes… question.
Select **Exit** (E) to return to the start menu.

4.2. Using WinDyn:
Select **Calibrate channels** from the main menu.
Select the pressure channel to which the pressure is being applied.
Select **Calibrate.**
Enter the correct value obtained in 1. above and press OK.
Select **Done.**

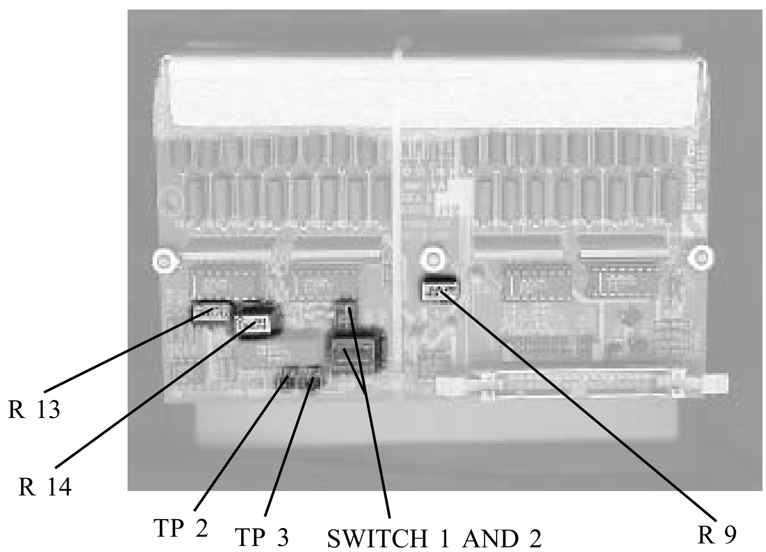
*

NOTE The standard configuration files have been designed for standard AutoDyn pressure transducer configurations. If different sensor ranges are used, the configuration files should first be changed using the DEF Configuration Editor before attempting to calibrate the sensors using the method described above.

20.3.5. Temperature channels (type K thermocouples)

The temperature channels do not normally require field calibration. If temperatures appear to be incorrect, compare the temperature readings of your AutoDyn to an accurate calibrated thermometer. Should calibration be necessary, follow this procedure:

1. You will need an accurate thermocouple calibrator (this is an instrument which is capable of simulating the thermocouple sensor signal for a temperature of your choice)
2. Remove the thermocouple panel from the box but make sure it is plugged into the NGE sensor system



3. Set switches 1 and 2 to the “CALZ” position
4. Using a precision digital multimeter (DMM), measure amplifier output voltage between TP2 and TP3. Adjust R14 until the voltage reads zero.
5. Set the switches back to “RUN”
6. Set the thermocouple calibrator to room temperature and plug it into one of the thermocouple inputs. Adjust R9 until the temperature readout for this channel on the AutoDyn matches the temperature on the calibrator.
7. Set the thermocouple calibrator to 1800 degF (US units) or to 1000°C (metric units). Adjust R13 until the temperature read-out for this channel on the AutoDyn matches the temperature on the calibrator.
8. Set the thermocouple calibrator back to room temperature and verify that the room temperature input reads correctly.

20.3.6. Air temperature and humidity sensor

The air temperature and humidity sensors are both built into a single probe. They cannot be calibrated in the field. If the measured values appear to be incorrect, contact your Service representative for repair or replacement of the sensor.

20.3.7. Optical tachometer

The optical tachometer does not require calibration other than entering the correct number of pulses per revolution in the Specifications file.

For the optical tachometer, use Specifications channel **87**. The default value is 1 pulse per revolution.

20.3.8. Ignition spark pick-up

The ignition spark pick-up does not require calibration other than entering the correct number of pulses per revolution in the Specifications file.

For the ignition spark pick-up, use Specifications channel **83**. The default value is 0.5 pulse per revolution.

20.3.9. Air flow sensor (SuperFlow air turbine)

The air flow sensor will be one of three available air turbines produced by SuperFlow. These turbines are individually calibrated and linearized at SuperFlow. The calibration is tracked by turbine serial number (engraved near the cable on the side of the turbine). Contact your Service representative with this serial number if you cannot locate the calibration information for your sensor.

The calibration values normally supplied with the air turbine consist of:

- an offset: this is the minimum flow required to produce an output signal
- a frequency at a flow of 900 cfm (424.71 l/s)

These values must be calibrated for each turbine in channel 7 using the DEF Configuration Editor. See the section on the Configuration Editor for more details.

Advanced users only

For the utmost accuracy it is possible to obtain the complete air turbine calibration sheet from SuperFlow. This sheet includes the output frequency of the turbine for ten different test flow ranges. Channel 135 of the DEF Configuration has been reserved for this information. Should you wish to use this feature, you will have to modify your air flow channel calculations and references to include this channel.

20.3.10. Fuel flow sensor (SuperFlow fuel turbine)

The fuel flow sensor will be one of two volumetric fuel flow turbines available from SuperFlow. These turbines are individually calibrated by the manufacturer and linearized by SuperFlow. The calibration is tracked by turbine serial number (engraved on the body of the turbine). Contact your Service representative with this serial number if you cannot locate the calibration information for your sensor.

The calibration value normally supplied with the turbine consists of a frequency at a mass flow of 300 lbs./hr, assuming a reference fuel with a specific gravity of 0.75.

This calibrated value must be entered in the formula for channel 58 using the DEF Configuration Editor. A default value of 124.6 is used in the standard configuration files supplied with the AutoDyn.

See the section on the Configuration Editor for more details.

Advanced users only:

For the utmost accuracy it is possible to obtain the complete fuel turbine calibration sheet from SuperFlow. This sheet includes the output frequency of the turbine for each of several test flow ranges. Channel 133 of the DEF Configuration has been reserved for this information. Should you wish to use this feature, you will have to modify your fuel flow channel calculations and references to include this channel.

20.4. Loading a *.prg file into your AutoDyn test system

* **NOTE** The *.prg file is the application program which determines what system you are using (e.g. an AutoDyn or a SF-602), how the system operates, what menus are available on the handheld controller, how system calibration procedures work, and much more. The *.prg file resides in Flash memory inside the sensor box of your system. No *.prg file should be loaded unless specifically requested and provided by SuperFlow Customer Service personnel. A new *.prg file will typically be sent to you if a system software update is available.

20.4.1. Install Wizard

20.4.1.1. Overview

This procedure is accessed from the WinDyn™ main menu via **Tools|Update Remote System Software**. Selecting this function allows you to automatically update the software located in the SuperFlow NGE data acquisition systems found on your network. These systems may contain sensor boxes, handhelds, fuel systems, table top systems, and other devices as appropriate for your NGE system type.

20.4.1.2. Using

Step 1: Prior to updating the system software:

a) Install any EPROM's that may have been provided,

b) ensure that the system is powered on and functioning correctly within the network for this computer, and

c) ensure that that the dynamometer is not in use and no tests or calibrations are in progress.

Step 2: Select **Tools|Update Remote System Software** from the WinDyn main menu.

Step 3: After reviewing the initial information on the "SuperFlow Automated System Update Program" window, click '**Proceed**' to proceed.

Step 4: A warning message will appear. Please review and click '**OK**' when ready to proceed.

Step 5: This procedure will now interrogate your network to locate and identify any SuperFlow systems. When completed, a new window will appear instructing you to select the system to update. Click '**OK**' after selecting the system. If your system does not appear, click '**Cancel**' and try to correct the problem before running the procedure.

Step 6: The update procedure will automatically proceed. No further user intervention is required. Please wait until the entire procedure is complete (about 1 minute). The "SuperFlow Automated System Update Program" window will indicate the current action being performed. A status bar will be updated to indicate an approximate percent completion of the entire procedure. Please do not perform any other WinDyn function while the update is in progress.

Step 7: Wait until the procedure indicates "Update complete...". The status bar will have been removed and the '**Finish**' button enabled. Click the '**Finish**' button to exit procedure.

This system has now been updated and is ready to use.

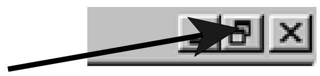
20.4.1.3. Functional Description...

This procedure first interrogates your network to locate and identify any SuperFlow systems. You will then be prompted to select the system to update from a list. After the selection is made, this procedure will first retrieve the current calibration information for the system. Following this, the software for your system will be downloaded into each node. These nodes may be a sensor box, handheld, fuel system, table top unit, and other devices as appropriate for your NGE system type. Following the download, each node is reinitialized and communications will be reestablished with WinDyn. After this initialization, the previously saved calibration information will be returned to your system. The system will then be ready to use.

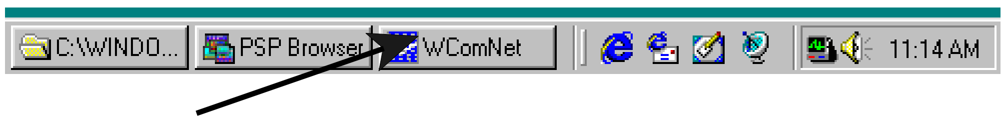
*	**NOTE**	If you have a 602 product with a fuel system, this procedure will not retain the fuel system calibration information. After performing this update procedure, you will need to recalibrate your fuel system.

20.4.2. From WComNet

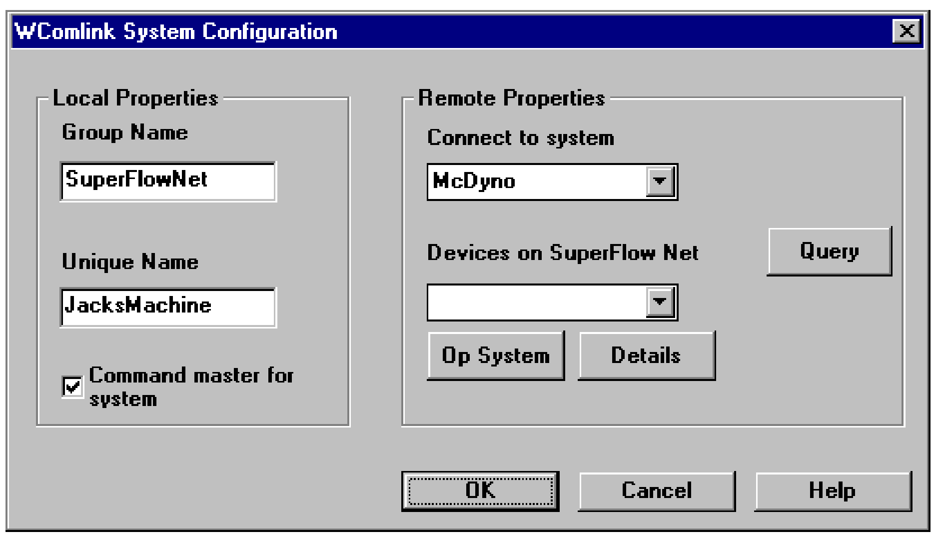
1. Minimize the WinDyn window by clicking on the minimize button in the top right hand corner of the display.



2. Click on the WComNet button on the task bar at the bottom of the screen.

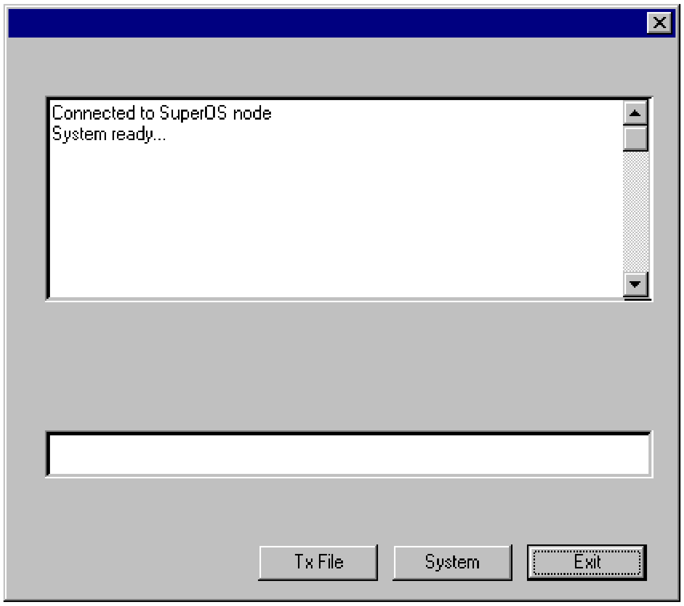


3. Click on Configure|System in the WComNet window. The display will now show the WComLink System Configuration screen



4. Click on Query
5. Click on the pull-down arrow under "Devices on SuperFlow Net". There should be one label, similar to this aAutoDyn...01.
6. Click on aAutoDyn...01
7. Click on Op System
8. Enter the password "booga" (in lower case!).
9. The display will read:

   Connected to SuperOS node
   System ready...



10. Click on Tx File

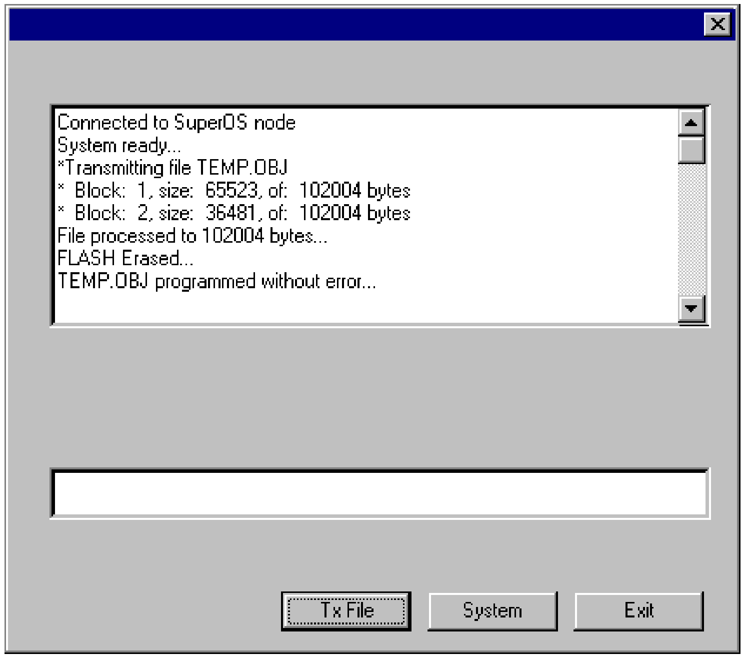
11. A file selection dialog box opens. We assume the new *.prg file has been provided to you on a floppy disk. Install the floppy disk in the A drive and change the drive selection to the "A" drive in the dialog box.

* **NOTE** If a new *.prg file was downloaded via modem or provided to you in another manner, you will have to select the proper drive letter and file location in this dialog box. Make sure you select the new file and not the original *.prg!

12. At least one file with the extension .prg should appear. Your customer service engineer will inform you of the proper filename. Click on that file name to select it. Verify that this file is now shown in the "File name" box and click on OK.

* **NOTE** On AutoDyn Pro systems you will have to download two *.prg files, one for the "A" processor and one for the "B" processor. To download the second (B) .prg file, return to step 10. above once the first (A) file is successfully downloaded.

13. The *.prg file will now be saved to the Flash memory inside the sensor box of your test system. The display will show a message similar to this:



* **NOTE** For the "B" file in "Pro" systems, the same message will appear but with reference to the B processor.

14. Click on Exit to return to the WComNet System Configuration window.
15. Click on OK to restore normal communication between the PC and the test system. WcomNet status should show "Connected to AutoDyno".
16. Exit WinDyn and WComNet. Power off the Sensor Box, wait 5 seconds, and power it back on.
17. Press the System Status (C) key on the handheld controller. The *.prg filename will be displayed. Confirm that it is the new version which you just installed.
    For Pro systems: press the B-Proc (B) key to check the B-processor *.prg.
    Press Exit (E) to return to the power up menu.
    Press Start Menu (A).
18. Restart WinDyn.

Appendix A

General Testing Information

Appendix A

General Testing Information

A.1 Torque Capacity Rating

The SuperFlow hydraulic dynamometer carries a nominal capacity rating of 1000 lbs-ft,(1350N-m), of torque and 1000 HP (750kW). This can be upgraded to 2000 lbs-ft (2700N-m) via an optional strain gage. Nevertheless, the endurance limit of the shaft is much less. While many of our users have run numerous tests in the 800 to 1500 lb-ft, (1100 to 2000N-m) range, these have typically been short in duration. When endurance tests are run for hundreds of hours, the maximum torque limit is 430 lbs-ft,(580N-m) for 833 absorbers. If you run for a long period of time at a level above 430 lbs-ft, the shaft will break eventually. SuperFlow 871 absorbers have twice the endurance limit.

The maximum power is limited first by the maximum torque the absorber can resist at a given speed, and second by the maximum water flow rate through the dynamometer. The standard straight vaned absorber will not reach 1000 lbs-ft, (1350N-m), of torque until approximately 4000 rpm in pressure boost mode, and the optional angled vane absorber will not reach 1000 lbs-ft of torque until approximately 2800 rpm in pressure boost mode.

As speed increases to the 6000 to 8000 rpm range, the outlet water temperature of the dynamometer begins to rise to above our recommended limit. We prefer to keep the dynamometer outlet water to 160F (70C). The faster you run the engine, the hotter the water becomes and at approximately 8000 rpm, the absorber may exceed the maximum operating temperature.

Your dynamometer will not simply fail at that point, but it may begin to show some steam and there may be some difficulty in holding the load. One good solution to this is to run low temperature inlet water to the dynamometer when you have a very high power engine. The dynamometer capacity on 50F (10C) inlet water is considerably greater than it is at 100F (38C) inlet water.

If you exceed 1000 hp (750kW), there is not necessarily any damage to the dynamometer. We have had documented reports of customers running as high as 2800 hp (2088kW) through the dynamometer for brief periods.

A.2 Fuel Flow When Accelerating

You only have to run a few tests on an accelerating engine with your SuperFlow Dynamometer system to discover that the power output and the air-fuel ratio change with the speed of acceleration. An understanding of fuel flow within the engine can shed light on these changes. What happens to fuel delivery when the engine is accelerating? How does fuel flow differ when the engine is running at a steady speed?

When an engine is running at a steady speed, fuel is mixed with air and travels down the port as spray flow. Some of the fuel is vaporized and behaves exactly as air does. Other fuel remains in droplet form. These unvaporized fuel droplets partially coat the walls of the ports with a film of liquid fuel as a result of turns and general turbulence. This film creates a slow moving flow along the wall which ranges from 0.010" to 0.020", (1.2 to 2.5mm), thick. Moving much more slowly than the spray flow, this fuel moves down the port and breaks off at the valve, where it enters the cylinder as additional spray droplets. When the engine is running at a steady speed, the wall flow and the spray flow reach a point of equilibrium, delivering the desired air-fuel ratio to the cylinder.

When the engine speed changes suddenly, as during acceleration from 4,000 rpm to 5,000 rpm, the spray flow rushes to the new equilibrium point almost immediately, but the slow moving wall flow requires almost 100 engine cycles before it reaches the higher flow level. The net result is that the engine cylinder receives insufficient fuel at the increased speed operating point for the first 100 cycles. The engine runs lean, and may stumble and miss. The traditional solution is to add an accelerator pump that delivers extra fuel during the transition. This additional fuel travels down the port primarily as spray flow and works to overcome the momentary lag in the wall flow fuel delivery.

When the engine is already running at full throttle under rapid acceleration, the accelerator pump has no effect. In this case, the normal solution is to increase the jet size so that the engine will run richer. Unfortunately, the engine then always operates rich during full throttle; a richness that is greater than necessary if the engine was running at a constant speed. That is why the engine may stutter or blubber due to a rich air-fuel ratio.

On the dynamometer, you will generally find that the engine requires one or two steps richer to achieve maximum power under acceleration tests than during steady state tests at the same speed.

In a race car application, engines frequently accelerate at different speeds, rates, and times. First gear acceleration might exceed 2,000 rpm a second, while fifth gear acceleration may be less than 100 rpm a second as a vehicle reaches top speed. The same air-fuel delivery ratio will not be correct in both situations. Currently, mechanical carburetor systems do not compensate for this problem. Some fuel injection ECM modules can be tuned to compensate for this effect.

If you want to determine how much enrichment is required for your particular engine, it is necessary to run a series of tests at progressively richer settings at each of the acceleration rates your engine will experience in its normal application. You will probably discover that the richest setting is required for the highest rate of acceleration and the leanest setting for the best steady speed power. You cannot determine the correct mixture by the air-fuel ratio, but only by the net power produced. For a performance engine application, you should select the mixture for the acceleration rate that will be used the greatest portion of the time.

To determine how quickly air and fuel flow systems respond during acceleration testing, you can perform a simple manual test. Run the engine at a constant speed, such as 3000 rpm at full throttle. Manually record data by rapidly pushing the record button.

After 3 seconds, continue to record data rapidly and increase the engine speed rapidly by advancing the engine speed control knob upward approximately 500 rpm. Let the engine run another 10 seconds at this point while you continue to record data manually as rapidly as you can.

If you view this set of test data, you will see the actual air and fuel flow delivery readings: first at 3000 rpm and then at the higher test speed. By comparing the data changes over time, you can determine how long it takes to reach a stable reading. Also examine the power. Power will stabilize sooner than the fuel flow due to delays in fuel flow measurement.

This test should be the worst possible combination because you are making the most rapid step change possible. You will probably discover that it requires 5 to 7 seconds to reach a stable data point.

Production engines experience this problem to a lesser degree because of increased manifold heat and the higher vapor pressure of typical pump gasoline. The extra manifold heat evaporates the wall flow back into the air stream and also promotes vaporization of the droplets of fuel and the spray flow. Unfortunately, manifold heat also increases the temperature of the air charge and reduces the volumetric efficiency at maximum power.

A.3 Air Flow Measurement

The SuperFlow air flow turbines used to measure air consumption of the engine on your dyno can provide some very valuable information when evaluating the engine's characteristics.

Given the importance of air flow, you are missing some critical information if you do not measure air flow. Volumetric efficiency, air flow, air/fuel ratio and brake specific air consumption become critical missing links in your engine test program.

The air flow turbine fan spins at a speed that is directly proportional to the volume flow rate. SuperFlow air turbines are calibrated at 6 test points by comparison to standard orifices. This test is actually performed on a flowbench, but the flowbench only compares the air turbine readings to the standard orifice flows. A special mathematical formula correlates the orifice flow reading in CFM to the air flow turbine frequency. The six flow orifice test data points are entered into the WinDyn computer program.

The air flow volume is measured and transmitted to the data acquisition system. The data is processed and calculated with the local barometer, vapor pressure and carburetor air temperature to provide the displayed data in Standard Cubic Feet Per Minute (SCFM) (Normalized liter per second or Nl/s). SCFM is what the air flow would be if the atmospheric conditions were measured at reference conditions, e.g. a barometric pressure of 29.92 inches of mercury, 60 degrees F, and no water in the air (dry vapor pressure).

As a rule, an engine will consume approximately 1.25 SCFM of air per horsepower (0.8 l/s per kW) at peak torque while using approximately 1.4 SCFM (0.9 l/s) at peak power.

Look at the Volumetric Efficiency (VE) and the Brake Specific Air Consumption (BSAC) columns. If the VE percent is very high (>100%) and the BSAC is substantial (>6.0 lbs/HPhr or 3700 g/kWh), there is a good indication that some of the air and fuel that could have helped to make more power went right through the engine and was wasted. You should therefore check for a poor valve sealing or faulty camshaft design.

If the flowbench investigation (surely you checked things out on a flowbench!) indicated that you have parts that should make strong power but the dyno results are lower than expected, start by looking at the air related information the dyno provides for the solution.

When measuring air flow, be aware that pulsations in the air flow, or in the fuel flow for that matter, will cause errors in the reading. Each engine induction cycle causes a pulse in air flow. Because the fan blades are not symmetrical to air flow for forward direction versus backward, pulsating air flow will cause the turbine to read consistently high or low, depending on its design and the frequency. At higher pulsation rates, this result tends to be very small. When running at lower speeds, pulsations can cause significant errors.

For instance, a four cylinder engine running at full throttle at 1500 rpm will have substantial airflow pulsations. The frequency is low enough that the flow rate can be in error by as much as 15%. The solution is to add a dampening drum between the engine and the air flow sensor. The damping drum should have a volume of 30 to 100 times the volume of the engine displacement. A 50 gallon (200l) barrel can be hung from the ceiling, and connected to the engine with a 12-inch (30cm) diameter flex tube. The air turbine is attached to the end of the damping drum and the pulsation problem is minimized. This solution will work well on a 4, 6, or 8 cylinder engine.

Please note, the readings from SuperFlow flowbenches cannot be used to directly calibrate the air flow turbines. The flowbench compares the flow through an orifice to the flow through the test item. At sea level temperature and pressure, the air turbine and the flowbench readings will be the same. At all other air densities, the flowbench flow will differ from the air turbine flow by the square-root of air density. For this reason, it is recommended you send you air turbines to SuperFlow to be recalibrated at least annually.

A.4 Flow Bench Correlation

It's widely known that the internal combustion engine is an air pump. With that in mind, modifying an engine design to maximize its air flow will generate more power. Using your SuperFlow flowbench and dynamometer in tandem will produce a reliable testing team in your on-going search for power.

When a cylinder head, intake manifold or head and manifold together are placed on the flowbench for evaluation, the temptation must be resisted to automatically make all the holes larger for one important reason: air flow is more dependent on the shape than it is on size. Air flow testing becomes mandatory in order to precisely gauge the air flow capability of the components. What "looks about right," usually is not.

The complete intake system can be evaluated on the flowbench to indicate the level of power that the system will produce. The maximum air flow at a test pressure of 25 inches of water multiplied by 0.27 will estimate the horsepower (per cylinder) that the components can make. (When a test pressure of 10 inches of water is used, the formula becomes the flowbench reading multiplied by 0.43). This number may shift slightly if the engine is not matched with the components or if the engine is extremely efficient. This estimated power versus air flow number is a reliable indicator of predicted performance.

Your flowbench can also produce a close estimate of the speed at which peak power will occur. This determination is made by dividing 1266 by the displacement of one cylinder and then multiplying the result by the maximum air flow measured at a test pressure of 25 inches of water.

This will lead to one final calculation regarding torque: peak torque will be achieved at approximately 75 to 76 percent of the engine speed for peak power.

There are many factors to consider for these estimates to be accurate. Key among them is the assumption that the engine's components are matched or will be "tuned" correctly for maximum air flow. If an engine has components to effectively operate mechanically at 7,500 rpm, but has air flow capacity to turn 10,000 rpm for peak power, it may never make the trip to the finish line!

In addition, these formulas were derived for typical automotive 4-cycle V8 type gasoline powered, normally aspirated engines. The formulas may not predict reasonable values for engines of different configuration.

For additional information, refer to SuperFlow Flowbench manuals.

A.5 Oil Temperature Control

Every experienced dynamometer operator understands that oil temperature affects engine power. For any extended testing, *an oil cooler is mandatory*. When using an oil cooler, it is important to note that the cooler can only control the temperature of the oil entering the engine. The temperature of the oil exiting the engine is a function of the oil flow rate and engine heat rejection.

The typical flow rate for an automotive engine is approximately one gallon, (4 liters) of oil per minute for each 1,000 rpm of engine speed. As oil passes through the engine, the oil temperature will rise 20 to 60°F, (11 to 33°C), depending on power and speed. A rise of 60°F should be considered the maximum for engine operation. A greater temperature difference means the oil is either too thick or too thin at some point in the engine lubrication cycle. Industrial and race engine designers try to limit the oil temperature difference through the engine to approximately 20°F, (11°C), for minimum wear and block thermal distortions.

The oil temperature should be kept constant during an engine test. A variation of 10°F (6°C), can change measured power by 1%. SuperFlow's optional oil cooling system works with both wet and dry sump oil systems. It is important that the engine oil pass through a filter before entering the oil cooler. If your engine should fail during testing, the oil cooler can be contaminated and will be difficult to clean.

A.6 Torque versus Speed

All 4-cycle engines running on gasoline without supercharging, tend to develop approximately the same maximum torque per cubic inch of displacement. This number is approximately 1.35 to 1.55 lb-ft of torque per cubic inch of displacement. This can also be expressed as a BMEP of 200 to 230 psi.

Despite the best efforts of engine builders over the past 40 years, nothing has improved this number appreciably. (Again, this number is valid only for 4-cycle engines without supercharging running on gasoline, no matter what the size.)

A more important determinate of power is the engine stroke. The speed at which an engine develops its engine power is usually determined by the stroke. Typically, maximum power is developed when the average piston speed is between 4,000 and 4,500 ft/minute, (20 to 23 meters/second.)

Because power is equal to torque multiplied by speed divided by a constant (HP = torque x speed / 5,252.113), and because the maximum torque for a given displacement is constant, the power per cubic inch is directly proportional to engine speed. Since engine maximum speed is inversely proportional to engine stroke, the shorter the stroke, the more power per cubic inch the engine can develop.

For example, an engine with a 3-inch stroke will develop maximum power at approximately 8,000 rpm, while an average engine with a 1.5-inch stroke will develop maximum power at approximately 16,000 rpm. While the maximum torque per cubic inch will be exactly the same for both engines, the maximum power per cubic inch will be twice as great for the shorter stroke engine.

A.7 Fuel Injection Return flow

Many new injected engines bypass part of the fuel and return it to the fuel tank. This introduces a problem in measuring total fuel flow. While the SF-902 dynamometer can be configured to subtract the fuel flow in one channel from the fuel flow in the other, this frequently produces errors due to temperature difference, aeration, and pulsation problems.

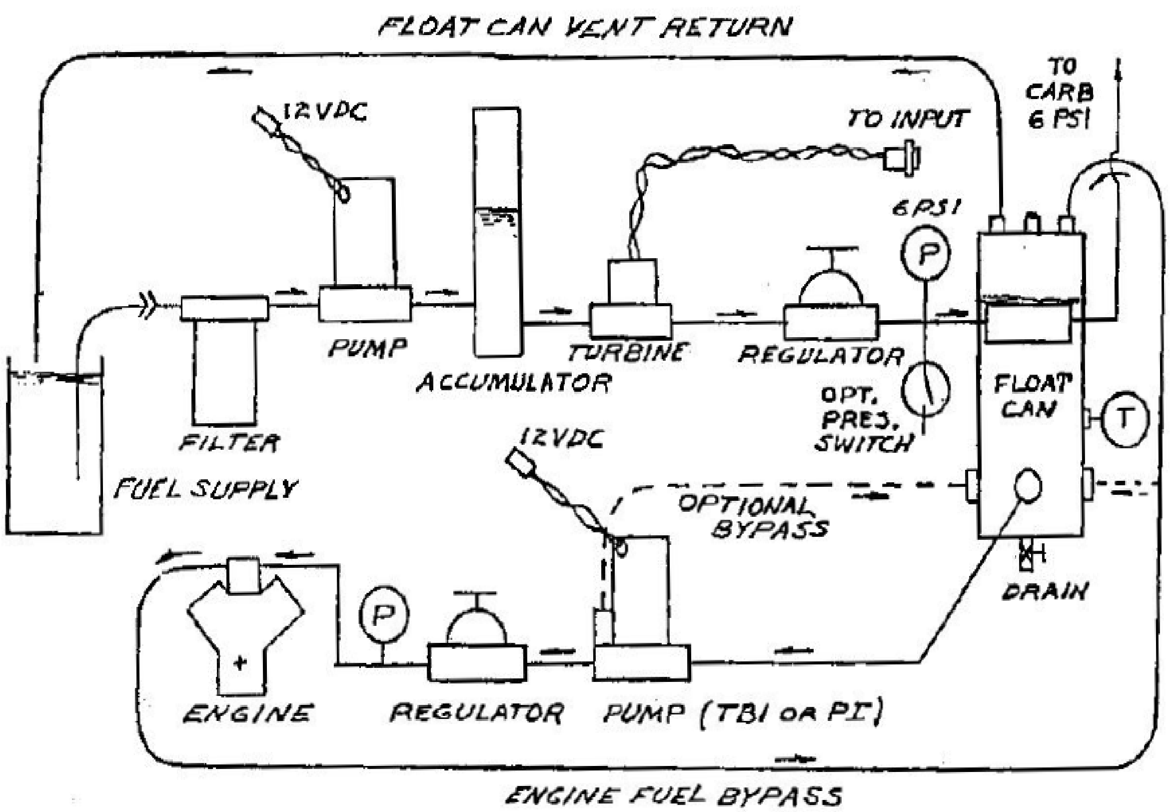


Figure A-1 Fuel Canister Schematic

A better way is to use an intermediate float system (Figure A-1). Fuel is delivered from the SuperFlow engine stand front panel to a float can or canister (Figure A-2). With throttle body or port injection systems, this can then supplies the pressure pump that supplies the injection systems. The bypass fuel is returned to the float can. Cooling coils may be added to the setup if the return fuel is heated.

The engine dynamometer now measures only the makeup fuel flow to the system. The return fuel flow causes no error. For typical production engines, fuel flow systems of this type are available from SuperFlow.

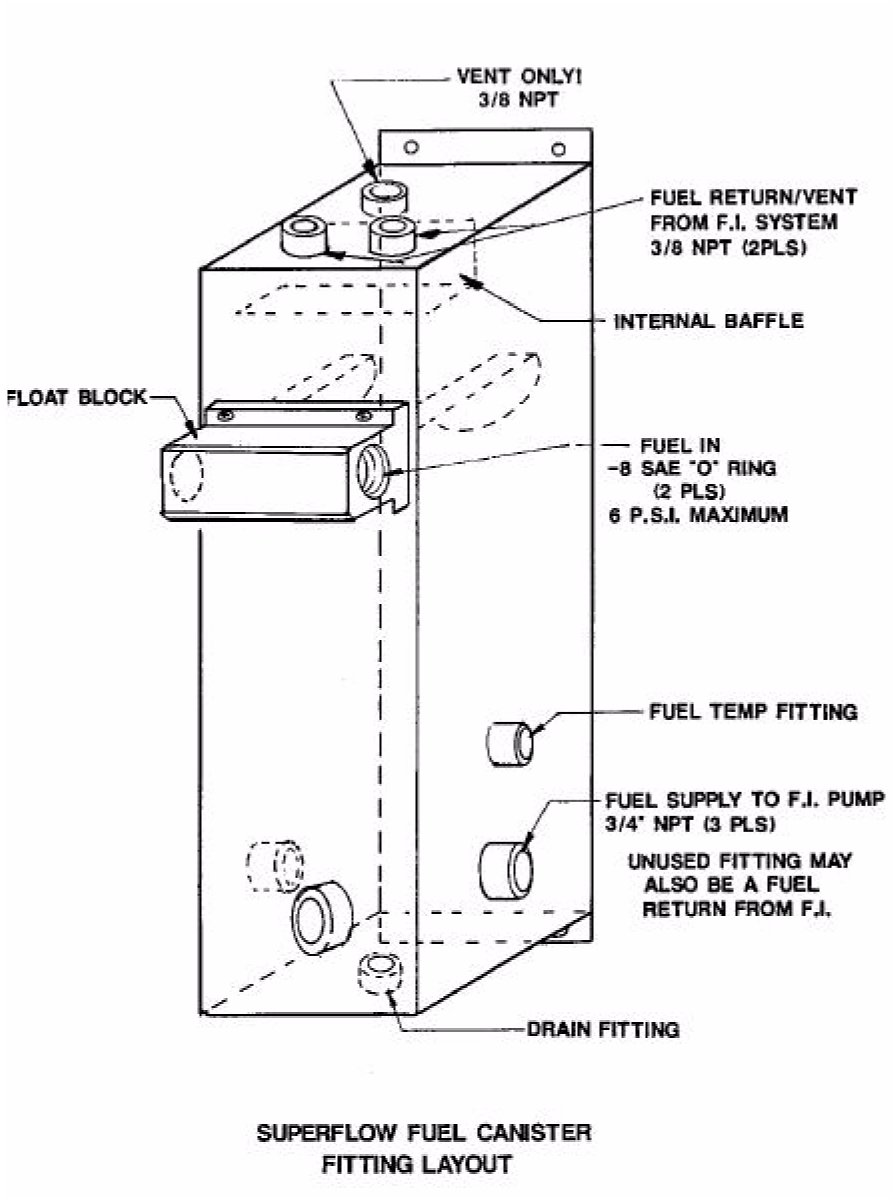


Figure A-2 Fuel Canister

A.8 Cleaning Fuel Filters

SuperFlow's high capacity fuel pump system also has high capacity filtration capabilities. The end result is that regular cleaning of the fuel filter is necessary to insure consistent fuel delivery. Sure signs of a clogged fuel filter are slow priming times for the pump and decreased fuel handling capacity during operation. The fuel system's filtration factor is determined by its 40 micron (0.0015 inch) capacity filter. This high capacity filter will trap grit, rust, flakes, lint, animal hair and insect parts. If you are not testing with highly filtered fuel, your fuel system will have the primary responsibility to catch the large quantity of contaminants you may not have realized were even present.

To clean the system, remove the filter screen assembly from its canister and wash it using a parts washing solvent. Never clean it with carburetor cleaner. After the filter has been cleaned, blow the cleaning solution and any remaining particles off of the screen using an air hose. Hold the nozzle of the hose at a 45 degree angle and blow air from the outside toward the inside of the filter element.

Depending on the source of your fuel, regular cleaning schedules will vary. At the outset, we recommend you clean the filter weekly.

A.9 Thermocouple Information

SuperFlow utilizes four kinds of type K thermocouples (yellow connector blocks, temperature range from 0-1800 degrees F). Each one utilizes two wires to relay the temperature signal.

Table A-1: Thermocouple Specifications

Use	Diameter	Length	Wire gage	Time Constant
Air, Exhaust	0.25", 6.35mm	5", 127mm	20#, 0.028"dia	< 0.3 sec
Fluids	0.25", 6.35mm	5", 127mm	20#, 0.028"dia	<10 sec
Air, Exhaust	0.125", 3.17mm	5", 127mm	28#, 0.020"dia	< 0.18 sec
Fluids	0.125", 3.17mm	5", 127mm	28#, 0.020"dia	< 4 sec

SuperFlow has recently switched to 0.125" thermocouples for the SF-902 systems. These provide faster response times for improved data acquisition. Two types of 0.125" diameter thermocouples in a 5" tube length feature either a closed or an open end. Twenty eight gauge wire (0.020" diameter) is used in both. If the open end version is employed for measuring air temperatures, you can expect a response time of less than 0.18 seconds; the closed end thermocouple will require a 10 second reaction time in an air stream. In liquids, their response time is less than 4 seconds. Keep in mind, the trade-off for faster response times is less longevity. The 0.125” open tip probes will require more frequent replacement if used for exhaust gas temperature measurement.

A 0.25" diameter thermocouple tube is available in a 5" length with an open thermocouple end. Utilizing 20 gauge wire (0.0285" diameter), it is ideally suited for measuring temperatures of air or exhaust gases. Its response time to a step change in temperature is approximately 0.3 seconds. This response time is a function of the thermocouple and not a limitation of software.

A second 0.25" diameter thermocouple tube also has a 5" length and uses a closed end. Also fitted with 20 gauge wire (0.0285" diameter), the closed end model is specifically designed for measuring fluid temperatures. The response time for temperature changes in fluid is approximately 10 seconds. (While this closed end version could be used to measure air temperatures, the air response time is much greater).

Proper placement of the thermocouples is critical to proper exhaust gas measurement. The thermocouple must be placed in the high velocity flow area of the exhaust pipe to obtain uniform readings. As a rule, a protrusion of at least 0.31" (8mm) into the gas stream is a minimum placement figure. Most of our users report very good results at 0.37" (9mm) protrusion. It is also important to index the open end of the tip so gases flow evenly across both types of wire and through the opening.

Thermocouple readings are affected by the radiation of heat from the surrounding pipe. Cast iron exhaust headers, for example, run hotter on the interior surface and radiate heat back to the thermocouple. As a result, the thermocouple can read up to 150°F (80°C) hotter than with a thin-walled steel header pipe. Conversely, pipes which are cooled with an air blower will register a lower temperature reading than uncooled pipes, even though the gas temperature is actually the same. You will also notice that stainless pipes have a different heat reflection than mild steel.

Because the exhaust gases are only flowing over the thermocouples for about 40% of each engine cycle, the temperature readings average 150 to 200°F, (80 to 110°C), less than the true average exhaust gas temperature.

Two final factors which induce fluctuations in thermocouple readings are contamination and vibration.

Proper maintenance procedures for these thermocouples should include cleaning the plug contacts periodically. At any time during a test that you encounter erratic thermocouple readings, your first troubleshooting procedure should include unplugging and plugging the thermocouples to regain contact which may have been sacrificed by vibration. You can normally spot a loose contact by lower than normal temperature readings. On the other side of the spectrum, an erratically high temperature reading is often the result of ignition noise.

If you require specialty thermocouples for other categories of temperature measurements, there are many thermocouple manufacturers. The only requirement for inclusion into the SuperFlow dynamometer system is that the thermocouples be type K (other types can be used if the system is configured for those types with the proper electronic module).

We recommend using ungrounded types, as they induce less radio frequency interference (RFI) noise into the data acquisition and control system. A grounded thermocouple will respond faster, but will also introduce ignition noise into the system. Any thermocouple you install should have a shielded wire cable if it is to be applied to a spark ignition engine. You may also use an Ohm meter to check if the thermocouple is shorted to ground or open.

A.10 Barometric Pressure

A very critical aspect of your dyno test procedure is barometric pressure readings. First, remember that the barometric pressure figure with which you work must be the uncorrected barometric pressure. This will be different than the relative barometer reading given by a weather station. You must get the barometric pressure for the local altitude, temperature, and gravity.

SuperFlow dynamometer systems are equipped with a barometric pressure transducer and will keep track of current barometric pressure conditions. However, just as you must calibrate the torque system occasionally, you must also check and calibrate the barometric pressure transducer. The first step is to obtain a valid barometric pressure reading.

If calling an airport or weather station for barometric pressure, be sure to ask them for an "uncorrected station barometric pressure reading in inches of mercury." Keep in mind, as a rule of thumb, for every 1000 foot elevation above sea level, the barometric pressure will drop approximately 1 inch of Mercury. So, if they give you a barometric pressure reading of 30.01 inHg, and you are at an elevation of 2000 feet, they have given you the "relative" barometer and not the actual station pressure. Ask again. The reading should be more like 28.01 inHg.

A better solution is to buy your own wall-mounted Mercury column barometer. Be sure to correct the readings for temperature and gravity as described in the instructions included with the barometer. There are several sources for these instruments. One good one is PRINCO instruments. As of January, 2004, they can be located on the internet at http://www.princoinstruments.com/.

A.11 Noise Interference

RFI (radio frequency interference) and EMI (electro-magnetic interference) are always a problem with electronics around high output ignition systems and other high energy devices. Both can occur simultaneously. The radiated energy from a high frequency section on a TIG welding machine even can cause interference. The way we isolate our electronics and the way we suggest for our customers to address the phenomena specifically apply to our equipment. We have had a very good success at these applications and our customers typically work with all the various high output ignitions, including the high energy, high frequency plasma units.

- Carefully separate all sensors and cables from close proximity with the ignition wires.
- Do not run a sensor cable parallel with an ignition wire.
- If a sensor must cross the path of an ignition wire, make it happen at 90deg if possible (and with space between).
- You might want to explore putting a Faraday cage (device for shielding electronic noise) around your ignition amplifier.
- The amplifier (ignition) case should probably be grounded (check with manufacturer of ignition).

- Keep the coil wire (when used) to less than 18" in length.
- Verify ground paths from spark return to battery (a very good filter in itself).
- Do not leave a timing light connected while running tests.
- Check all the above often.

Appendix B

Fundamental Concepts to Obtaining Superior Repeatability

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Fundamental Concepts to Obtaining Superior Repeatability

The following concepts were originally presented by Jim McKenzie of Hendrick Engines Dynamometer Labs during the 1998 AETC conference. These are intended as guidelines for using an engine dyno and obtaining maximum repeatability in your results. Following these guidelines can result in +/- 0.1% repeatability. We've added additional info and hope this provides you with the necessary guidelines to get the most from your SuperFlow product.

B.1 The Dyno Cell

- Air flow across the engine is a must. It must be sufficient to evacuate the test cell at least 8 to 10 times per minute. Look for 1-1.75" water pressure drop in your test cell.
- Engine intake air should be sealed off from the environment inside the test cell. The engine should draw its air from the shop if possible, or use outside shop air. Additionally, you may add a fan to purge air in the plenum.
- Use some type of exhaust system and keep it sealed as well as possible. Many times you will be working in the test cell with the engine running. Hazardous fumes will be present unless you use some type of exhaust. Also, consider noise abatement requirements for your area and use mufflers where required. Critical grade industrial mufflers are a good choice. You also want little or no back pressure in your exhaust system.
- Make sure your water system is adequate for your testing needs. You will use approximately 10 gallons per minute for every 100 horsepower (5-6 gpm if you are not running a cooling tower). To rapidly warm up engines, a separate pre-heated water system can be employed, but it is recommended to use the dyno water system for engine cooling. Pressurized cooling towers will increase repeatability and will allow testing of the engine under more realistic conditions.

B.2 The Dynamometer

- Calibrate, calibrate, calibrate!!! Insuring your dyno's torque measurement system is correctly calibrated is critical to obtaining repeatable results. The Hendrick team calibrates before and after each test. Other teams calibrate every morning and keep a log of calibration results. All use precision weights. Also, insure you have loaded correct calibration values for your fuel and air turbines.

- Keep your dyno in good operating condition and follow the proper maintenance procedures. Change the absorber oil at least every 60-100 hours of operation with 10w30 synthetic oil (60cc for standard absorber, 120cc for 871 absorber). Keep your dyno and test cell clean. Preciseness comes from cleanliness!

- Keep spare parts available. SuperFlow recommends a zero-downtime kit consisting of servo valves, engine speed pickups, water filters and absorber pump seals. Those parts and a few others are essential to have on hand during crunch time. Contact a SuperFlow Customer Service Engineer for details and ordering.

- Oil and water temperature management is absolutely essential for repeatability. SuperFlow sells a pressurized cooling tower and an oil cooling heat exchanger. Invest in both.

- Fuel system management is also critical. Fuel flow and pressure rates should be consistent. Fuel temperature must also be maintained to get repeatable BSFC and A/F ratio numbers. Fuel temp is also critical to power repeatability.

- Air flow measurement is crucial. It provides BSAC and volumetric efficiency numbers. Make sure your air turbines are calibrated. Send them back to SuperFlow yearly to have them checked. Keep your calibration numbers handy so you can verify the proper ones are loaded in your software.

- Buy a mercury barometer to obtain the correct barometric pressure reading for calibrating the dyno. Correct the reading for temperature and gravity.

B.3 The Operator

- Be smooth and consistent.

- Start every test of record with the same oil and water temperatures.

- Develop appropriate test methodologies and routines specific for your application. For instance, Hendrick Engines tests from 5400-8700 on open motors and 4900-7300 on restrictor plate motors. They use 100 RPM accel rates and critically monitor oil and water temps. Allow the engine to stabilize at an RPM before pressing START to begin the test.

- Average your test data before attempting to analyze it. The WinDyn software allows multiple tests to be averaged together. Use a minimum of three tests. Engines simply don't repeat well, so by averaging the tests, you'll get a much more realistic picture of what the engine is doing. You can also average columns of data in WinDyn.

- Always optimize the engine after any changes. Try to return to the same A/F ratio setting before determining if the change made an improvement or not.
- Also, optimize the A/F ratio for atmospheric conditions. Hendrick Engines uses O2 sensors in each cylinder and one in each collector. They believe O2 sensors are crucial for repeatability.
- Try to minimize the correction factor, if possible. Don't dyno on "bad air" days.
- Systematically return to the baseline configuration during the course of your testing. This helps insure the improvements you saw were indeed from the changes you made.
- As atmospheric conditions change, re-establish the correct A/F ratio.

B.4 The Engine

- The engine must be properly broken in using your established break-in procedure.
- The engine's state of tune is critical for good repeatability. A badly running engine simply will not repeat.

B.5 Tuning tips

- Remember, G-forces can't be duplicated on the dyno, so jetting on the dyno will be different than jetting required on the track.
- Jet for maximum power, and let BSFC fall were it may.
- Use step testing to jet and to work on BSFC. Step testing is far more accurate than accel tests for jetting work.
- Typically, for every 100 RPM change in acceleration rate, you lose approximately 2-3 lb-ft of torque. Most circle track teams test at 100 RPM acceleration rates. Drag racers use 300 or 600 RPM rates.
- The best way to measure A/F ratio is through the use of O2 sensors. Hendrick Engines uses 10, one in each header tube and one in each collector.
- The Air Turbine must be on straight and sealed to get repeatable results.