Baja Dyno Operating Procedure

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Table of Contents

Section

1 Manufacturing plan/prints
1.1 Engine stand (On Baja server)
1.2 Sprocket hub (On Baja server)
1.3 Head tapped for pressure sensor

2 Operating Procedure

2.1 Mechanical Setup
  2.1.1 Load Cell
  2.1.2 Engine/stand Placement
  2.1.3 Drive system/chain tensioning
  2.1.4 Chain guard
  2.1.5 Throttle system/kill switch
  2.1.6 Room exhaust system
  2.1.7 Thermocouple placement
  2.1.8 Encoder placement/tiny tach
  2.1.9 0-2 sensor placement
  2.1.10 Mass air flow sensor placement
  2.1.11 Pressure sensor placement

2.2 Software/Electrical Setup
  2.2.1 Load cell/dyn-loc controller
  2.2.2 Thermocouple lab view interface
  2.2.3 Engine encoder system (TFX software)
  2.2.4 0-2 sensor system (LM-2 kit)
  2.2.5 Pressure sensor system (TFX software)
3  Troubleshooting

3.1 National Instruments SCXI modules

3.2 LM-2 Digital Meter for the oxygen Sensor

3.3 TFX Software for the pressure transducer / charge Amplifiers

3.4 Load Cell and encoder from Dyno-Loc IV Controller

4  Appendix

4.1 641RM Dwyer instruction manual

4.2 TFX installation and setup manual

4.3 TFX data collection and analysis manual

4.4 TFX PV diagram help

4.5 Kistler pressure sensor

4.6 Dyn-loc controller manual

4.7 LM-2 instruction manual

4.8 Sensor test plan

4.9 Sensor validation document
1 Manufacturing plan/prints

1.1 Engine stand
(On the Baja server)

1.2 Sprocket hub
(On the Baja server)

1.3 Head tapped for pressure sensor

Purpose:
To install the Kistler pressure sensor in a modified head, one must machine the head according to the following procedure.

Procedure:

1) Place head in mill such that a line drawn between the centers of the two valve openings would create a 30 deg. angle with the horizontal. The intake valve should be higher than the exhaust valve, and the internal portion of the head should be facing the operator.

2) Align the x-axis of the mill such that the center of a cutter is lined up with the raised corner of the head. Lock the table in this position.

3) Tilt the head of the mill 5 deg. back so that when the sensor is installed it will protrude into the corner at an angle and allow there to be more clearance for thread engagement.

4) Clamp a gauge block (1”X1.5”X3” works well) to the face of the head such that the top of the block is level and the bottom is flush with the apex of the corner. The upper back corner of this block will be the reference point to allow the head to be drilled correctly.

5) Find a center cutting end mill that is around 0.600” to create a pocket in the fins and a flat surface to drill into.

6) Determine the appropriate centerline for the operations by touching the top and back face of the gauge block and setting the centerline of your mill such that it comes directly into the corner of the gauge block.

7) Measure the distance between the back face of the gauge block and the internal face of the head. Call this distance X. Your distance to offset back in the Y direction is given by equation 1.

\[
\text{Offset} = \frac{X}{2} + h \times \tan(5\degree)
\]

Where h is the vertical height of the gauge block. Offset the mill.

8) Once the mill is in position lock all axes and only move the quill. This will ensure that the operations follow the proper centerline.

9) Plunge mill down far enough that there is a flat on the head.
10) Place a center drill in the mill and follow procedures 6-8 to set the centerline properly. Use the center drill to start the hole.

11) Drill a pilot hole that is about 3/16” into the head. The centerline should once again be set using procedures 6-8.

12) Place the provided step drill into the mill and follow the diagram provided by KISTLER for the rest of the dimensions. All operations must follow the same centerline. The step drill should be plunged until it just barely protrudes into the head.

13) The flat that was placed on the head may need to be machined down further, that measurement should be based off of the depth that the step drill was drilled to.

14) Tap the top of the hole according to the diagram using a 10-24 tap. The dummy sensor should seat properly.

15) Ensure that the head and hole are clean and free of burrs.
2 Operating procedure

2.1.1 Load cell

Purpose:
To properly measure the torque output of an engine there needs to be some device to measure it. The load cell measures the force seen by the dyno in reaction to the engine.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM-500 load cell</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) The SM-500 load cell should already be calibrated. If you need to adjust it place a known weight on the end of the dyno lever arm and set the dyn-loc controller as is laid out in the dyn-loc manual.
2) Read the torque the dyno-loc controller outputs in the top right when the power is on. It should be three times whatever the weight you placed off the end of the dyno lever arm. If it is not follow the procedure laid out in the Dyn-loc manual on how to calibrate the torque settings.

3) In the event that the load cell is not in place or needs to be replaced make sure that there are two people present to do so.

   i) Remove the present load cell by taking out the bolt connecting it to the stand and unscrewing the nut that holds it to the lever arm. Make sure to have the second person steadying the DC motor while doing this so that it does not shift in the process.

   ii) Put the new load cell in place in the same fashion that the old was removed. While doing this it may be necessary to adjust the rod ends to ensure that the DC motor is level. This can be done by placing a level on top of the motor and screwing the rod ends in or out as needed.
2.1.2 Engine/stand placement

Purpose:

The Briggs and Stratton engine is securely fastened to the engine stand so it will remain in place while running. The engine stand is bolted to the dyno table to prevent the whole drive system from becoming misaligned.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembled stand</td>
<td>1</td>
</tr>
<tr>
<td>10 HP Briggs Engine</td>
<td>1</td>
</tr>
<tr>
<td>3/8&quot; bolts</td>
<td>8</td>
</tr>
<tr>
<td>3/8&quot; lock washers</td>
<td>8</td>
</tr>
<tr>
<td>3/8&quot; flat washers</td>
<td>16</td>
</tr>
<tr>
<td>3/8&quot; nylon nuts</td>
<td>8</td>
</tr>
<tr>
<td>5/16&quot; bolts</td>
<td>4</td>
</tr>
<tr>
<td>5/16&quot; flat washers</td>
<td>8</td>
</tr>
<tr>
<td>5/16&quot; lock washers</td>
<td>4</td>
</tr>
</tbody>
</table>

Procedure:

1) Take the assembled stand and place it on the dyno stand as shown in the picture below. Make sure the eight bolt holes in the stand cross beams line up with the holes in the dyno table.

2) Place 8 3/8" bolts through the holes in the engine stand and tighten 4 to 5 turns. Secure with nylon nut, lock washers, and flat washers. (You will tighten them securely when you tension the chain.)
3) Place the engine on the stand plate shown in the orientation below. Place four 5/16” bolts in the holes of the engine base plate. Secure with nut, lock washer, and flat washer. Tighten the nuts firmly.
2.1.3 Drive system

Purpose:
The drive system transmits the torque the engine produces from the small sprocket on the engine to the large sprocket on the dyno via a roller chain.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.5'' dyno sprocket</td>
<td>1</td>
</tr>
<tr>
<td>3.82'' engine sprocket</td>
<td>1</td>
</tr>
<tr>
<td>525 chain</td>
<td>1</td>
</tr>
<tr>
<td>Machined hub</td>
<td>1</td>
</tr>
<tr>
<td>Sprocket hub set screw</td>
<td>1</td>
</tr>
<tr>
<td>engine sprocket bushing</td>
<td>1</td>
</tr>
<tr>
<td>shear bolts</td>
<td>2</td>
</tr>
<tr>
<td>1/4''-20 bolts</td>
<td>5</td>
</tr>
<tr>
<td>Encoder wheel</td>
<td>1</td>
</tr>
<tr>
<td>Encoder bracket</td>
<td>1</td>
</tr>
<tr>
<td>Screws for bracket</td>
<td>4</td>
</tr>
<tr>
<td>Encoder hub</td>
<td>1</td>
</tr>
<tr>
<td>Encoder hub set screw</td>
<td>1</td>
</tr>
<tr>
<td>Engine shaft end bolt</td>
<td>1</td>
</tr>
<tr>
<td>End bolt washer</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Attach the dyno sprocket on the dyno hub with the lettering facing the door. Attach 5 ¼''-20 bolts in each of the 5 bolt holes. Make sure you use a lock washer. Tighten the bolts in a star pattern.

2) Place 4 3/8'' dyno hub bolts into the steel hub and tighten securely.
3) Place the steel key into the keyway of the output shaft of the engine.

4) Take the assembled encoder wheel/encoder hub and place it on the output shaft of the engine making sure the keyway of the hub lines up with the steel key. Take the assembled engine sprocket/hub and place it on the output shaft of the engine. To assemble the sprocket onto the hub, use two grade 2 bolts. Insert the encoder hub set screw and tighten 2-3 turns only. Insert the sprocket hub set screw into the hole and tighten the same amount. You need the hubs to be loose so you can adjust the chain alignment in the next step. Make sure you use thread locker on the set screws.

5) Insert the 3/8” bolt with a lock washer and flat washer into the end of the output shaft of the engine. Make sure you tighten securely.
6) Using a level, make sure the face of the large sprocket and the face of the small sprocket line up. Continue to tighten the hub set screws until snug.

7) Slide the engine stand as far as it can go towards the dyno. Place the chain over both the dyno sprocket and engine sprocket. Connect the safety link in the chain and secure with the bracket and locking tab.

8) Slide the engine stand as far as it can go away from the dyno. Use a c-clamp to keep constant tension on the chain. The chain should have 1” of total travel directly in the middle of the two sprockets.
9) Tighten all but the 2 engine stand to mounting table bolts shown in the picture below and then remove the c-clamp.

Do not tighten
2.1.5 Chain guard

Purpose:
To comply with OSHA safety standards for a chain driven device, a complete enclosure had to be made to protect against flying debris if the chain/sprocket broke.

Materials Needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain guard</td>
<td>1</td>
</tr>
<tr>
<td>3/8&quot; bolt</td>
<td>2</td>
</tr>
<tr>
<td>3/8&quot; flat washer</td>
<td>4</td>
</tr>
<tr>
<td>3/8&quot; lock washer</td>
<td>2</td>
</tr>
</tbody>
</table>

Procedure:

1) Unbolt the two bolts shown below that hold the engine stand to the dyno table.

2) Place the chain guard, with the window facing the door of the dyno room, over the top of each sprocket as close to vertical as possible.

3) Place two 3/8" bolts through the chain guard brackets into the dyno table holes. Secure with a flat washer and lock washer and tighten the nut/flat washer on the underside of the table securely.
4) Place the two bolts you removed in step 1 through the chain guard, engine stand, and the dyno table securing with a flat washer and a nut on the underside.
2.1.4  Throttle system / kill switch

Purpose:

The throttle of the engine is controlled by a direct connection, via a throttle cable, located in the dyne controller room. In case of an emergency, a kill switch is located in the dnye controller room and in the dyno room.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throttle cable</td>
<td>1</td>
</tr>
<tr>
<td>Throttle adapter</td>
<td>1</td>
</tr>
<tr>
<td>Screws for adapter</td>
<td>2</td>
</tr>
<tr>
<td>Nut</td>
<td>1</td>
</tr>
<tr>
<td>Washer</td>
<td>1</td>
</tr>
<tr>
<td>Kill switch</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Place the throttle adapter onto the engine and secure with 2 socket head cap screws.

2) Slide the throttle cable through the adapter and tighten the two screws.

3) Wrap the exposed throttle cable wire around the screw on top of the washer.
4) Place the nut over the wire and tighten securely. Attach the spring to the throttle bracket and to the frame of the engine shown below.

5) Connect the black wire from the engine to the black wire from the kill switch by twisting them together and securing with tape or a wire cap. Connect the other wire from the kill switch to a grounded wire by twisting it together and securing with tape or wire cap.
2.1.6 Room exhaust system

Purpose:
The exhaust system evacuates the engine fumes from the dyno room allowing people to work safely in the room.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room exhaust tube</td>
<td>1</td>
</tr>
<tr>
<td>Movable cart</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Place the exhaust tube on a movable cart. Make sure the end of the tube is 4-8 inches from the muffler outlet and not touching the chain guard.

2) Turn on the fan by flicking the switch located directly under the fan housing on the wall.
2.1.7 Thermocouple placement

Purpose:
The thermocouples we are using are going to measure various temperatures on the engine and the air around it. These will be used in conjunction with other measurements to calculate fuel flow.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>K type thermocouple</td>
<td>4</td>
</tr>
<tr>
<td>Thermocouple probe</td>
<td>2</td>
</tr>
<tr>
<td>Electrical tape</td>
<td>roll</td>
</tr>
<tr>
<td>Modified oil plug</td>
<td>1</td>
</tr>
<tr>
<td>Modified muffler bong</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Connect each thermocouple wire into the yellow box beneath the dyno table. Refer to the picture below for placement.

2) Place the air intake thermocouple on the MAF tube with tape. Make sure you place it on the outside of the tube (Disregard placement on picture).
3) Place the two block thermocouples in the location shown below.

4) Place the muffler temperature probe into the fitting and tighten the fitting. Connect the yellow plug to the probe.
5) Place the oil temp probe into the brass plug and tighten the fitting. Connect the yellow connector plugs together.
2.1.8 Encoder placement/tachometer

Purpose:

The encoder system is used to obtain the rpm that is seen at the engine shaft. It is important to know this for safety reasons and future development work.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiny tach</td>
<td>1</td>
</tr>
<tr>
<td>Encoder sensor</td>
<td>1</td>
</tr>
<tr>
<td>Encoder nut</td>
<td>2</td>
</tr>
<tr>
<td>Gap setting device</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

Encoder:

1) Place the encoder with the flat portion of the sensor parallel to the engine shaft. With the top nut unscrewed feed it through the bottom of the encoder bracket. Use the supplied plastic device to set the gap between the bottom of the wheel and the top of the sensor. There should be 100 thousands clearance provided by the tool. Tighten the top nut securely.

2) Connect the encoder sensor wire to the TFX system shown in the TFX setup procedure that is located in the program files on the computer.

Tachometer:
3) Wrap the red wire 5-6 times around the spark plug wire. Loosen the muffler mount screw and place the ground wire under the nut. Tighten the nut securely.

(Nut to tighten)

6) Place the tiny tach in the window of the dyno room by taping it on the wall.
2.1.9 Oxygen sensor placement

Purpose:
The oxygen sensor needs to be in an ideal location to record the air to fuel ratio that the engine is operating at.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen sensor (LM-2 Kit)</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Place the oxygen sensor into the bung on the muffler. Tighten securely with an adjustable wrench.

2) Connect the oxygen wire leading from the oxygen sensor, to the matching wire that runs through the wall to the dyne controller room.
2.1.10 Mass air flow sensor placement

Purpose:

The MAF sensor records the speed of air that goes into the engine. It is important to know this to obtain other parameters like fuel flow rate.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAF sensor</td>
<td>1</td>
</tr>
<tr>
<td>MAF bracket</td>
<td>1</td>
</tr>
<tr>
<td>MAF bracket screw</td>
<td>1</td>
</tr>
<tr>
<td>Rubber bushing</td>
<td>2</td>
</tr>
<tr>
<td>MAF tube</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

1) Connect the MAF bracket to the throttle adapter with a bolt from below shown in the picture.

3) Slide the air flow sensor through the bracket hole with the rubber bushing installed and then through the MAF tube. Make sure the sensor is parallel to the face of the tube and almost touching the far side of the tube.
4) Connect the red and black cables into their designated holes in the MAF sensor box. Make sure the BNC cable is run through the wall and into the dyne controller room. Plug the other end of the BNC cable into the dyn-lock controller. Plug the MAF box into an electrical outlet.

5) When using the MAF sensor it is necessary to set the range of the sensor. This is done by opening the control box and setting the parameters as laid out by the 641RM Dwyer instruction manual found in appendix 4.1.
2.1.11 Pressure sensor placement

Purpose:

The pressure sensor will measure the peak pressure in the cylinder. This will tell you how the engine is running and if it’s creating max power.

Materials needed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified head</td>
<td>1</td>
</tr>
<tr>
<td>Kistler pressure sensor</td>
<td>1</td>
</tr>
</tbody>
</table>

Procedure:

If using the Kistler sensor:

1) Connect the TFX sensor wire to the sensor in the pre-drilled head. Instructions in how to drill a head can be found in section 1.3.

If using the PCB spark plug pressure sensor:

2) Screw the spark plug into the head with the modified spark plug wrench. Do not over tighten the spark plug.

3) Connect the TFX wire to the PCB sensor wire as instructed in the TFX manual attached in the Appendix.
2.2 Software / Electrical Setup

2.2.1 Load cell / Dyn-loc controller

**Purpose:** The load cell and the dyn-loc controller will be used to output torque and dyno rpm to the lab view interface.

**Materials needed:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM-500 load cell</td>
<td>1</td>
</tr>
<tr>
<td>dyn-loc manual</td>
<td>1</td>
</tr>
</tbody>
</table>

**Procedure:**

1) Refer to the dyn-loc manual in section 4.9 for help in setting up the Dyn-loc controller.
2.2.2 Thermocouple labVIEW interface

**Purpose:** Acquired readings from thermocouples

**Materials needed:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple extension cable</td>
<td>1</td>
</tr>
</tbody>
</table>

**Procedure:**

1) Connect the thermocouple extension cable running from the dyne cell to the TC-2095 terminal block mounted on the rack.

2) Ensure that numbers on each thermocouple wire matches up with the channel number on the TC-2095. This should also match that indicated on LabVIEW.
2.2.3 Engine encoder system

**Purpose:** The engine encoder connects through the TFX hardware to obtain engine rpm to be used in conjunction with pressure data.

**Materials needed:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFX installation and setup manual</td>
<td>1</td>
</tr>
<tr>
<td>TFX data collection and analysis manual</td>
<td>1</td>
</tr>
</tbody>
</table>

**Procedure:**

1) Refer to the TFX installation and setup manual and the TFX data collection and analysis manual, located in section 4.2 and 4.3 respectively, to set up the encoder system.
2.2.4 Oxygen sensor system (LM-2 kit)

**Purpose:** Connect the LM-2 kit to oxygen sensor and DAQ hardware.

**Materials needed:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM-2 kit</td>
<td>1</td>
</tr>
</tbody>
</table>

**Procedure:**

1) Please, refer to the LM-2 kit manual.

2) Connect the LM-2 digital meter to sensor 1 input cable running from the dyne cell.

3) Connect the power cable via the provided cigarette adapter, to an AC outlet.

4) IMPORTANT: Connect the LM-2 digital meter to the PC using USB cable provided in the kit.

5) Finally, connect the customized analog out wire to CH 4 of the BNC-2095 rack.
2.2.5 Pressure sensor system (TFX software)

**Purpose:** The pressure sensors from Kistler and PCB are connected to a computer by the TFX software to obtain data and produce useful graphs.

**Materials needed:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFX installation and setup manual</td>
<td>1</td>
</tr>
</tbody>
</table>

**Procedure:**

1) Refer to the TFX installation and setup manual, and TFX data collection and analysis manual located in section 4.2 and 4.3 respectively.
3 Troubleshooting

3.1 National Instruments SCXI modules

System fails to acquire data or values reported are "off":

1) Reset the SCXI-1001 Chassis using Measurement & Automation Explorer (MAX) as described below.


ii) Expand "Devices and Interfaces" by left-clicking the + symbol. You should see SCXI-1001 name and number in the list.

iii) Right-click and select "Reset chassis".

iii) Now try, running the LabVIEW GUI. If problem persists, power cycle the chassis and reset it again following the steps described above.

Note: If the device does not show up in the list or still reports wrong values, refer to the National Instruments website ni.com/support for more troubleshooting tips.

IMPORTANT: Resetting the SCXI-1001 chassis can sometime change the configurations for the TC-2095 rack, making the muffler temperature max out at 300 degree F. If this occurs, simply follow the steps below to resolve the issue.

2) BNC/TC-2095 Rack
   - Temperature readings are "off"
   - Analog voltage readings are "off"
   - Muffler temperature maxes out at 300 degree F

NOTE: The BNC/TC-2095 are connected to the SCXI-1102C module. Because of the 2 Hz bandwidth of the SCXI-1102 module input channels, after changing the gains you must wait approximately 3 s for the channels settle in order to get an accurate measurement.
3.2  LM-2 Digital Meter for the oxygen Sensor

**IMPORTANT:** If the AFR/lambda value reported on LabVIEW GUI does NOT match the value on LCD on the LM-2 Digital Meter when the engine is not running, this is normal. Only inconsistent readings when the engine is running should be addressed.

1) Ensure that the USB cable AND the power cable are connected when taking measurements.

   - The LCD on the LM-2 Digital Meter is dim or no valid readings on LabVIEW GUI.

2) Check all power connections. Make sure the USB cable is connected to a USB port on the PC and the power cable/adapter is correctly connected. If using a cigarette adapter, ensure that the adapter has a min. of 1 A (1000 mA) current rating.
   Dim LCD indicates that the LM-2 Digital Meter is only powered by USB cable. When the power cable is connected, the LCD should be fully lit.

Inconsistent reading:

3) Check all power connections. Ensure that the USB cable AND the power cable are connected when taking measurements. The LM-2 Digital Meter MUST be connected to USB cable and power cable at the same time to get valid readings when the engine is running.

4) If problem persists and the reported AFR values on LabVIEW are offset, follow manual instructions to reconfigure the analog out 1 channel on the LM-2 Digital Meter. The default should work. Note that the voltage measured by LabVIEW is indicated on "Analysis" tab on the LabVIEW GUI.
3.3 TFX Software for the pressure transducer / charge Amplifiers

1) Refer to the TFX installation and setup manual for troubleshooting.

3.4 Load Cell and encoder from Dyn-Loc IV Controller

1) Refer to the Dyn-loc controller manual for troubleshooting.
Appendix

641 RM Dwyer instruction manual
4.2 TFX installation and setup manual
4.3 TFX data collection and analysis manual
4.4 TFX PV diagram help
4.5 Kistler pressure sensor
4.6 Dyn-loc controller manual
4.7 LM-2 instruction manual
4.8 Sensor test plan

Test procedures to ensure satisfaction of customer requirements

Requirements 1,2: Indicates and logs the horsepower and torque of the test engine as functions of RPM

Measuring Torque

1. Using the moment arm that is attached to the rear of the Dyno place a known quantity of weight three feet from the center of the Dyno shaft.
2. Initiate the LabView software and check that the value displayed by the software and by the Dyneloc controller correlate to the torque that is being applied to the system by the weight on the end of the shaft. The value displayed should be three times larger then the weight applied. If number does not match, consult procedures related to setting up the controller.
3. The LabView software should display the applied torque (same as controller readout) as well as the engine torque which will be lower by a factor of whatever the drive ratio is set to (currently 3.88)
4. Change the weight applied several times until the full range of expected torque values is displayed and verified using both instruments.

Measuring RPM without the Engine on Dyno

1. Ensure that nothing is connected to or near the Dyno shaft.
2. After clearing the room and closing the blast doors activate the Master button and the RPM button.
3. Set one of the dial switches to the desired value and press the active button that is next to it so that it glows red. (NEVER SET THE SWITCHES TO A VALUE LOWER THAN THE LAC-RATE)
4. Start the LabView software and then press the “DYNE ON” button. This will cause the dyno to spin at the set rpm. With the drive ratio set to one the LabView software should display the same number as the dyno, if it is a value other than one then the software should display whatever the Dyno-Loc displays multiplied by the drive ratio.
5. The data logging system should output the same values for the course of time that the system was active.
6. To achieve a transient response for the data logging set the second dial to a different number, and while running the software, press active on the second dial. The dyno will change to the desired speed and then hold it. The software should show this change on the screen as it happens, and it should be reflected in the data file.

Measuring Torque and HP as functions of RPM without Engine attached

1. With the Dyno off place a weight on the end of the moment arm as was done previously. Verify that the Torque reading is correct.
2. Ensure that the Dyno shaft is free to rotate and near it. Exit the Cell and close the doors.
3. Run the transient RPM test just as was done in step 6 of Measuring RPM.
4. This time the torque should remain constant throughout the course of the test, the RPM and the HP should change however. Ensure the logged HP is correct given the fixed torque and variable RPM using the equation to HP.

Measuring RPM, HP, and Torque with the Engine on the Dyno
1. Following the Run procedures run the engine through a full run 2-3 times and overlay the data to ensure it is consistent.
2. Since there is no secondary Dyno that can be used to check the same engine twice it will be necessary to compare the results obtained to those obtained using a different dyno and engine setup. This data has been provided by the Michigan Baja team and is available to comparison.

Requirement 3: Is easily disabled via a convenient "kill switch" in the operating room, as well as the monitoring room.

Check Engine kill switch in dyne cell.

1. Bolt engine to Dyno plate, but do not attach chain to dyno.
2. Check all connections to be sure that bolts are tight.
3. Turn on exhaust fan.
4. Start Engine using pull cord and allow it to run momentarily.
5. Depress kill switch to ensure it shuts down the engine. If it does not the spark plug wire can be pulled loose so that the engine shuts down, or fuel can be shut off.

Check Engine kill switch in control room

1. With engine bolted down as before start the engine with kill switches set to run.
2. After momentarily running the engine, depress the kill switch in the control room to ensure the engine shuts off. If not press the switch in the cell or pull the plug wire.

Check dyne kill switch in control room

1. Ensure that nothing is attached to or near the dyno shaft.
2. Set the dyno switches such that “MASTER” and “RPM” are lighted and then set one toggle switch somewhere between 300-500 and press the active button.
3. Press “DYNE ON” to start the dyno spinning.
4. Press the red “DYNE OFF” switch and ensure the dyno spins down of its own accord.
5. Press “DYNE ON” again so that the dyno spins back up to speed.
6. Press the “EMERG STOP” while watching the Dyno shaft. The shaft should be brought to an abrupt stop. (This button should almost never be used except in severe cases, its use can do serious harm to and engine or the drive components.)

Check dyne kill switch in cell

1. Follow same procedure as if checking the switch in the control room except instead of pressing the “EMERG STOP” button press the red stop switch that is in the Dyne Cell

Requirement 4: Allows user to pivot the engine 30° forwards and backwards with a minimum increment of 5°.
Check Pivot of stand.
1. With stand fully assembled and locator bolts in place, bolt the engine into the proper location.
2. Unbolt all side connections while holding the engine in place
3. With an assistant rock the engine to each 5° location and ensure that that bolts will thread into place
4. The stand should also be able to rotate between the 5° locations with two bolts in the slots
5. After checking that the stand has full rotation attach the stand to the Dyno plate and connect the chain (all circuit breakers should be off at this point as they should be every time the Dyno is being set up). Perform steps 2-4 again to verify that the stand can be rotated while mounted on the Dyno.

Requirement 5: Should be easy to set-up

Measuring time to set up: with all components in the Dyne Cell and the Dyno free of other components record the time to set-up the system and run one full test. An acceptable time has not really been established, however more that 1.5-2 hours would likely be unacceptable.

Measuring ease of set up: give the Baja team members the operating procedures and allow them to set up the system on their own and record and difficulties in following the instructions. Record these issue’s, improve upon them and allow another group of members to set up the system.

Requirement 6: Temperature reading and logging of data

Verifying Thermocouple function
1. Connect all wires for all Thermocouples but leave them off of the engine.
2. Initiate the LabView software and start logging data
3. All Thermocouples should be reading somewhere in the area of 72° F (Room temperature).
4. Hold the end of each probe/wire and ensure that the temperature increases to about 90° to 98° F (dependent on the temperature of your fingers)
5. Place the probes in ice water/snow and ensure that they read about 32° F
6. The data logging should show the appropriate temperature changes

Verify Repeatability of Thermocouples
1. Using the same procedure as describes about repeat the test a few times to ensure the same results (note: your fingers will not be the same temp each time this may not repeat but the room temperature should not change significantly so this should be repeatable)
2. Following all appropriate procedure to mount the engine, do so but leave the chain unattached.
3. Mount all thermo couples and start LabView software.
4. Start the engine in the proper fashion and record data for about one minute while running at idle.
5. Shut down the Engine and save the Data. Review the data to make sure all thermocouple readings are logical and close to what are predicted.
6. Run the Engine again when all Thermocouples go back to the reading they had before the start of the engine.
7. Compare the data, it will not be exact due to variations in the engine, but it should all be pretty close (10%?)

Requirement 7: Indicates and logs the Cylinder Pressure
Verifying Pressure measurement from Kistler
1. Look at instructions

Verifying Pressure measurement from spark plug system
1. Mount engine to Dyno stand but do not connect the chain
2. With the spark plug sensor in place start the data acquisition system and start the engine
3. Run the engine at idle for a short time then ramp it up to full throttle and then come back down.
4. Check the data to see if the pressure measurements match the expected results
5. Run the test again with both pressure sensors running and verify that both are achieving similar measurements and transitions.

Test Encoder
1. While running a regular Dyno test record data from both encoders and match the data, the corrected rpm and engine encoder should produce the same values (within 1% error?)

Requirement 8: Integration of O2 Sensor

Testing sensor placement and interference
1. Mount the muffler that is equipped with the O2 sensor to the engine and mount the engine to the stand.
2. Put chain guard in place and ensure that there is clearance of all components at all angles.

Testing functionality of O2 sensor
1. Mount Engine to stand without chain attached
2. Turn LabView software on and initiate data logging
3. Run engine and take data while at idle and then ramp the engine up to full throttle and back down.
4. Shut down engine and review data to ensure that the information was recorded and that it is logical.

Requirement 9: Indicates and logs intake air flow-rate of the test engine.

Test functionality of flow-rate sensor
1. Set up sensor as advised in the procedures and set up the engine on the Dyno stand (not attached to Dyno shaft)
2. Start the LabView software and initiate the data logging
3. Run the engine at idle and ensure that the sensor is taking data and that it is relatively constant (there is likely to be fluctuations but they should center around one value
4. Ramp the engine up to full throttle and then back down while recording data
5. Shut down the engine and check that air flow ramped up and then back down as the throttle changed
4.9 Sensor validation document