Measuring The Torque Output of Impulse Tools

= ??? N·m

Contents

Introduction

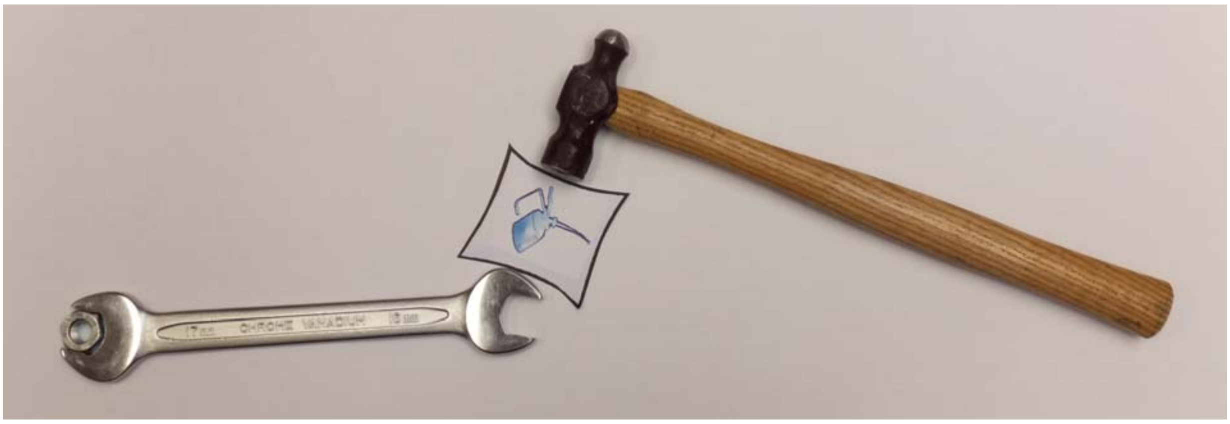
This document aims to highlight the difficulties in using and measuring the output of impulse tools.

Safety

Follow all safety warnings from tool manufacturers.

What is an impulse tool?

A hydraulic impulse tool (also called a pulse tool) can be thought of as an air powered hammer that acts on a hydraulic cushion to apply torque to the joint; this is shown in diagrammatic form below:



Impulse tools are lightweight with a high speed output and operate without reaction forces.

The impulse tool applies torque in a series of impulses (non-continuous rotation). A typical torque trace is shown on the right:

As torque increases the pulse narrows.

The main disadvantage is the difficulty of measuring the true applied torque.

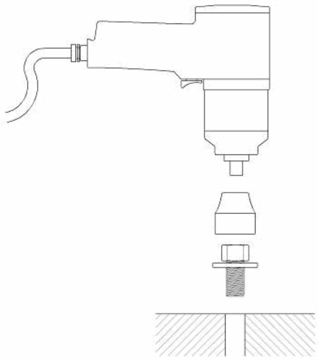
NOTE: Impact tools are similar to impulse tools, but without the hydraulic cushion. With an Impact tool the metal hammer acts on a metal surface; this is shown in diagrammatic form below.

Impact tools generate more noise and generate more vibration.

DO NOT USE <u>IMPACT</u> TOOLS WITH ANY NORBAR PRODUCT. IMPACT TOOLS HAVE A DESTRUCTIVE NATURE THAT CAN DESTROY THE ADAPTORS, RUNDOWN AND TRANSDUCER.

Using an impulse tool (without measuring the torque)

This section details considerations when using an impulse tool.
The most basic impulse tool set up would be:



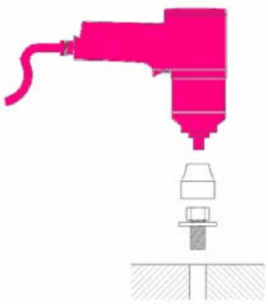
Impulse tools use air to operate a hydraulic mechanism that applies torque in a series of impulses.

If an impulse tool is operated in a consistent way that allows the joint to see the complete impulses, good results are possible.

To tighten to the correct value the operator must be consistent in the use of the tool.

The final joint torque depends on many factors, recommendation on how to deal with these factors are listed below:

IMPULSE TOOL



For the impulse tool to give consistent results it is recommended that:

1. All suggestions in the impulse tool handbook / manufacturers guides are followed (tool speed, air pressure, oil lubrication, settings, maintenance of air filters, maintenance of the tool, etc).

   There are many impulse tool manufacturers, including: Aimco, Accura, Atlas Copco, Chicago Pneumatic, Cleco, Cooper tools, Deprag, Ingersoll Rand, Stanley, Uryu & Yokota.

   Each manufacturer also produces a range of output capacities; these different tools may operate at speeds, use different size ‘hammer’ mechanisms, etc.

   The tool output is usually set by the input air pressure, but in addition some tools incorporate extra features including ‘Shut-off’ mechanism, a timer mechanism, transducer in line & torque setting.

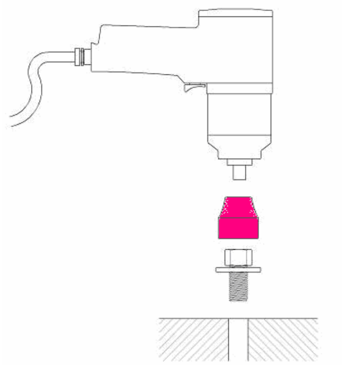
2. The air supply to the impulse tool is not restricted, is correctly filtered and has the correct oil flow (if required).

3. The impulse tool speed is correct (for shut-off impulse tools the shut-off mechanism will be affected by the speed the motor reaches before the pulse. A higher speed triggers the mechanism at a lower torque. The speed will increase if the air pressure to the tool is increased or when the oil level in the impulse unit is lowered).

4. The impulse tool is held rigid (held firmly by hand gives acceptable results). It is important that different operators all hold the tool in a consistent way, if the tool is held loosely results will be different.

5. During its life the impulse tool will wear, ensure the tool is regularly serviced.

ADAPTORS (sockets, socket set extension bars, rotary transducers, socket set universal joints, etc)



For adaptors to have a minimal effect on results it is recommended that:

1. Use a minimum number of adaptors.

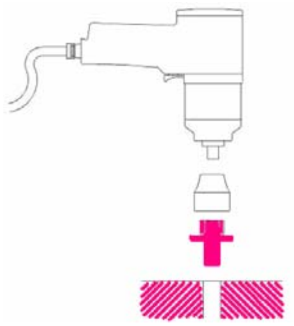
2. Ensure adaptors are a tight fit to stop potential rattle or slack. Replace worn adaptors, sockets and extensions.

3. Ensure adaptors have a low mass (changing the rotating mass will have a direct effect on the applied torque).

Excess adaptors can cause a shut-off impulse tool to take longer to shut off or not to shut off at all.

NOTE: Adaptors can affect the efficiency of the tool and increase torque scatter. The torque applied to the fastener can be reduced 20%, see Appendix D for details.

BOLTED JOINT



For the bolted joint to be correctly tightened it must see the full impulse tool output; this can be affected by:

1. The reaction under the joint must be solid, with no movement.

2. The torque rate (hard or soft joint); a hard joint has fewer impulses, this leads to a less accurate result.

3. The pitch of the thread can have an effect on the tool speed and number of impulses seen.

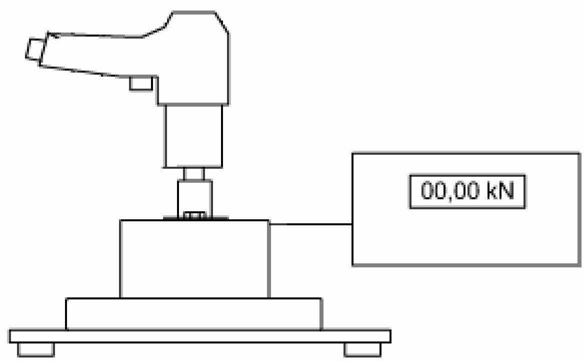
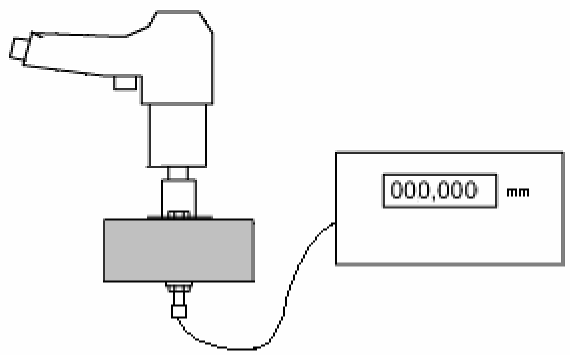
4. The bolted joint friction can have an effect on the tool speed and number of impulses seen.

Measuring an impulse tool

It may appear a simple task to measure the output of an impulse tool, but accurate and repeatable results are not always easy to obtain. Here are some quotes on the subject:

Source of quote	Quote from the introduction
ISO/TS 17104:2006 Rotary tool for threaded fasteners-Hydraulic impulse tools – Performance test method	"It has not so far been possible to achieve acceptable reproducibility of the correlated torque scatter….." "....test results from different test fixtures can be affected by differences in dynamic characteristics, thereby making direct comparisons difficult." "...torque scatter of fewer than ten percentage points should be viewed with caution..."
VDI/VDE 2649 January 2011. Rotary tools for bolted connection. Guideline for comparative power-measurements of hydraulic impulse tools.	"Directly traceable torque measurement is not feasible with impulse screwdrivers."

Both the above standards suggest load is measured as a comparative measure.
Examples of load measurement are shown below:

Test setup	Comments
	The performance of the impulse tool is measured using a load cell. As the bolt load changes slowly, the value can easily be measured.
	The performance of the impulse tool is measured using an ultrasonic bolt instrument (Norbar USM). As the bolt length changes slowly, the value can easily be measured. If it is possible to access the opposite end of the bolt, as shown, 'live' readings can be taken.

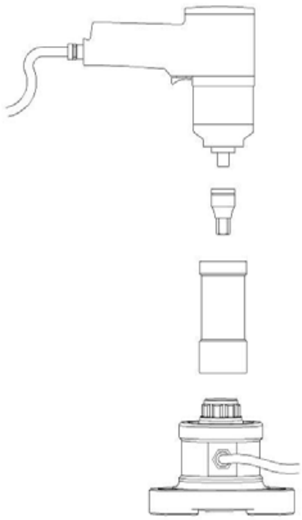
If a value of 'torque' is required the 2 main options are:

1. Torque transducer mounted with a joint simulator.

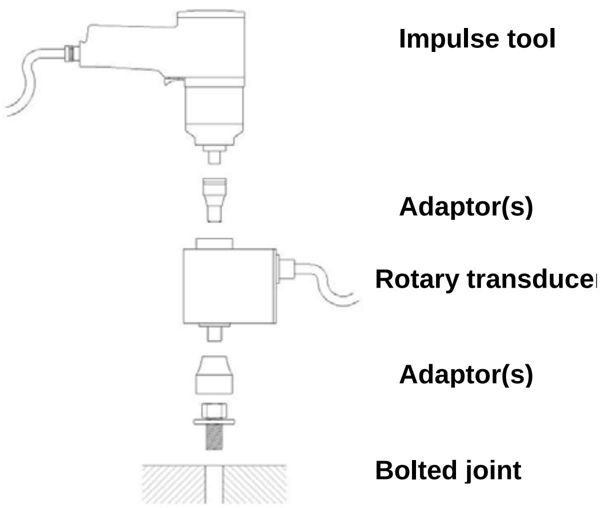
2. Rotary torque transducer in line with existing joint.

Each way has advantages & disadvantages, these are detailed below:

1. Torque transducer mounted with a joint simulator

Test setup	Comments
	Static transducer under joint simulator <u>Impulse tool</u> Ensure all the recommendations in "**Using a impulse tool (without measuring the torque)**" are followed. <u>Adaptor(s)</u> As this test is simulating the actual joint it is important to use the same adaptor(s) as with actual job. Any change in the adaptor type or number of adaptors can affect the results. <u>Joint simulator</u> Ensure the joint simulator is of a similar size bolt thread to the actual job. Ensure the joint simulator has a similar torque rate (hard / soft) as the real joint, see joint simulator for details of changing the torque rate. After prolonged testing the joint simulator may get warm, this could affect results. Ensure the joint simulator is maintained as detailed by the manufacturer. Check the bolt condition is good and all surfaces are still smooth and free from galling (metal pick up). Replace parts if necessary. Ensure the Joint simulator has a solid mounting to the transducer. <u>Static transducer</u> Pick the smallest transducer that will cope with the impulse tool, as a smaller transducer will be more sensitive. Ensure the static transducer is firmly attached to the work bench. A static transducer that uses a separate bench stand is NOT recommended, as the transducer can rattle due to being a loose fit in the stand. The Norbar FMT or STB style of transducer has the advantage of a more rigid reaction than the older style Norbar 'static' transducer. Ensure the work bench is rigid.

2. Rotary torque transducer in line with existing joint.

Test setup	**Comments**
	Rotary transducer in front of bolted joint <u>Impulse tool</u> Ensure all the recommendations in "**Using a impulse tool (without measuring the torque)**" are followed. <u>Adaptor(s):</u> Extra adaptors will add more mass, so affect the results. Keep the number of adaptors to a minimum. <u>Rotary transducer:</u> Use the lowest mass (smallest size) rotary transducer that will cope with the impulse tool. This will reduce the energy lost in accelerating the transducer with each impulse. Use a rotary transducer with drive squares that match the tool / bolted joint to minimise adaptors. Ensure rotary transducer brushes do NOT bounce. Ensure the rotary is held firmly (by hand gives acceptable results) to minimise any rattle or oscillation. (Rattle can cause extra pulses to be counted). <u>Bolted joint</u> With the extra rotary transducer (and possible adaptors) the joint will see less of the pulses generated by the impulse tool, so have a lower torque applied. If the fit of these parts is loose, the resultant torque will be less. TIP: To see an indication of the affect of the rotary transducer & adaptors try the following: A. With the rotary & adaptors tighten the joint. B. Mark the position of the bolt head against the surface. C. Undo the bolt. D. Remove the rotary & adaptors. E. Tighten the joint and compare marked position.

The static or rotary transducer can be measured in 1 of 2 ways:

1. Measure in a PEAK mode

This mode is available on instruments including the Norbar Pro-Log, TST, TTT and T-Box; all of which have a variable frequency response.

In operation the peak of the torque signal is recorded, with a filter used to reduce fast rising torque pulses that do not contribute to work done in the joint.
By adjusting the filter (frequency) setting it is possible to "tune" the mode to a particular impulse tool application.
Different impulse tools & different joints will lead to a different filter (frequency) setting.

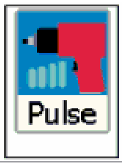
See Appendix B for more information of setting the correct frequency.

It is believed that in the past, some impulse tool manufacturers tested in an unrealistic way so a high torque output can be specified for their tool. Unrealistic methods include:

A. Measure the torque signal without any filter, so the very high frequencies of the pulses are measured (the torque may be measured, but is not doing any useful work to the bolted joint).
B. Setting the tool on a very high torque rate ("hard") joint to take advantage of the tool's momentum (if used on a low torque rate ("soft") joint the same torque would be impossible to obtain).

2. Measure in a impulse mode with algorithm.

This mode is available on the Norbar T-Box instrument.
Select by pressing the mode button shown opposite:



In operation each pulse is measured and software analysis is used to determine the work done by the pulse and so determine the torque achieved.

To use this mode follow the instructions in the T-Box handbook.

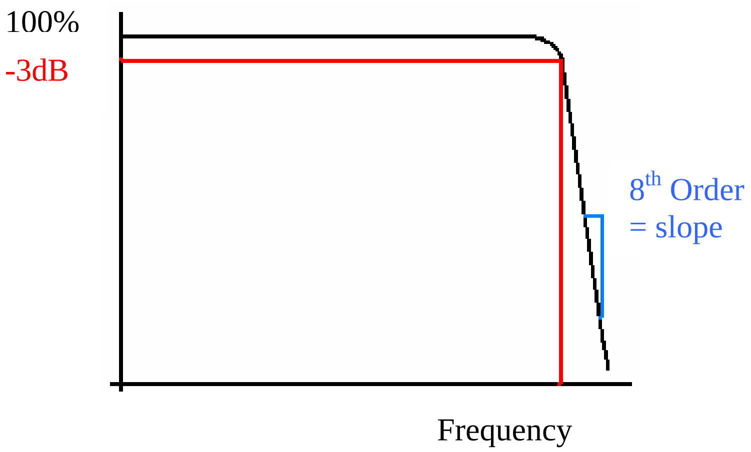
Whist using this mode the operator does NOT need to make any adjustments to the T-Box.
It is important that:

1. Results are taken above 20% of transducer capacity.
2. The pulse mode settings are not changed.
   (Keep Filter Frequency = 2500Hz and Active From = 4.8%).

Appendix A – Explanation of a filter

Filter

The Pro-Log, TST, TTT & T-Box signal filter is "8th Order Butterworth low pass filter with a –3dB point settable from 100 to 2500 Hz".



What does this mean?

8th order = slope.

Butterworth = Filter type (very flat pass area with NO gain).

Low pass = Pass low frequencies & ignore high frequencies.

-3dB = Frequency of setting.

Are all filters the same?

No, most competitors torque measurement product use a different signal filter.

Unless ALL filter specifications are identical the competitors filter will be different; just specifying "500Hz filter" is not enough.

Unless ALL filter specifications are identical, the results will be different.

Appendix B – Explanation of measuring at different frequencies in PEAK mode.

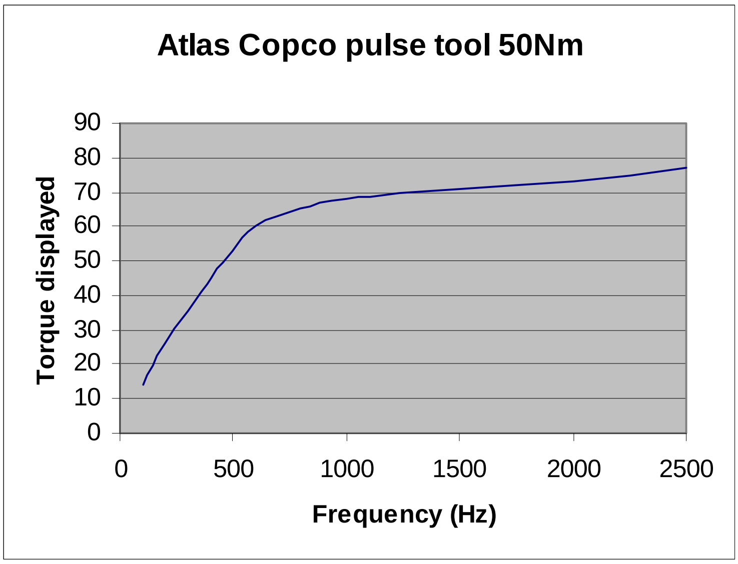
Why adjust frequency?
Different impulse tools create different types of pulses, small tools generally have high frequency pulses and large tools have lower frequency pulses.
The TST & TTT IMPULSE TOOL mode filter is set to 500Hz to give a good general result; but if the filter is "tuned" it is possible to obtain a better torque result for a particular tool.

How to "tune" the filter to measure impulse tools

1. Use a PEAK mode.
2. Test tool on joint and see torque displayed.
3. Mark exact bolt position.
4. Undo bolt and re-torque to same bolt position & note actual torque applied.
5. Repeat with a different filter frequency setting until torque displayed = actual torque applied.

Example of testing an Atlas Copco impulse tool at different frequencies:

Frequency setting	Torque displayed
100	14
200	26
400	45
500	53
600	60
800	65
1000	68
1500	71
2000	73
2500	77



Any changes to the tool, air pressure, joint, etc may affect this filter frequency.

Any torque value from 14 N·m to 77 N·m can be displayed for an actual applied torque of 50 N·m.

Appendix C – Verify the applied torque

The applied torque from an impulse tool can be measured using transducer systems from many different manufacturers, but is the result correct? Just because 2 different transducer systems give the same result does NOT guarantee a correct result. To ensure the correct result we need to verify the applied torque.

<u>Recommended method to verify the applied torque</u>

1. Mark the bolt head against the mounting surface.
2. Place a torque transducer (static, rotary, electronic wrench, etc) on the bolt head.
3. Undo the bolt whilst measuring the PEAK torque ("UNDO" torque).
4. Re-tighten the bolt to the marked point whilst measuring the PEAK torque ("REDO" torque).

The REDO torque is a measure of the previously applied torque.

TIP. How do we prove the "Verify the applied torque" method works?

1. Tighten a bolt manually using an accurate torque wrench or torque transducer ("TIGHT" torque).
2. Mark the bolt head against the mounting surface.
3. Place a torque transducer (static, rotary, electronic wrench, etc) on the bolt head.
4. Undo the bolt whilst measuring the PEAK torque ("UNDO" torque).
5. Re-tighten the bolt to the marked point whilst measuring the PEAK torque ("REDO" torque).

To obtain the best results so the "REDO" matches the "TIGHT" torque requires operator care and ensuring the "Issues in attempting to verify the applied torque" (below) are followed.

<u>Issues in attempting to verify the applied torque:</u>

Issue	Recommendation
Components	For best results tighten using all new components (bolt, washers, etc) and verify the applied torque directly after. Working with old components (that are used, warn, rusty, painted, etc) may well have an effect on accuracy.
Marking	Ensure the bolt is marked against a static surface; markings against a moveable part (e.g. a washer) will not work. Ensure tight bolt is marked with thin precise line between bolt & mounting surface. Place the mark at the position of the operator's eye when the bolt is re-tightened to reduce line alignment errors.
Lever	Using a longer lever to re-tighten the bolt will give the operator more control when getting the marks to match.
Joint type	If the torque rate is low ("soft" joint) it is easier to align the marks and get a good "REDO" torque. If the torque rate is high ("hard" joint) a small error in bolt angle has a large effect on torque, so requires more operator care.
Friction	If the joint has a low friction coefficient the bolt advances smoothly to get a good "REDO" torque. If the joint has a high friction coefficient the bolt advances less smoothly, so requires more operator care.
Repeated testing	Every time the test is repeated errors can occur, these include: Less friction due to the initial 'rough' surfaces on the bolt & mounting thread being smoothed. More friction if the metals are over stressed (galling). A temperature rise leading to a change in friction.

TIP. Why measure "UNDO" torque?

For a recently tightened bolt the "UNDO" torque is typically 60 to 70% of the tighten torque; this can be a useful check. The exact value depends on factors including joint type & friction.

Only if the bolt is old (rusty) or has been over stressed (galling has occurred) may the "UNDO" torque be larger than the original "TIGHT" torque.

Issues with "move on" or "just move" mode to verify the torque applied

Torque instruments and tools with a "move-on" or "just move" mode work by measuring the torque and angle as the applied torque is further advanced.

In theory when the bolt just moves the torque value is equal to the previously applied torque. In practice this may not be the case, with 150% overestimation of the applied torque easily seen, typical issues are shown below:

Issue	**Recommendation**
Angle setting	Most tools have an adjustable angle threshold; this is typically set to 3 degrees. If the joint is "hard" the angle may need to be reduced to improve the torque result.
Point of measurement	Different tools take a different point of torque measurement, or act in a different way. Points of measurements include: 1. Record the torque & angle continually so the value is known when the bolt started to move. 2. Record the torque after the bolt has moved through the specified angle; this can lead to an overestimation, especially on a high torque rate ("hard") joint. 3. Look for the small dip in torque value when the bolt moves; this may be difficult to detect for high torque rate ("hard") joints or high friction joints.
Joint type	If the torque rate is low ("soft" joint) the angle movement is easier to measure, so the torque result should be acceptable. If the torque rate is high ("hard" joint) the angle measurement can be very difficult to measure, this can easily lead to an overestimation of the applied torque.
Friction	If the joint has a low friction coefficient the bolt advances smoothly. The angle should be easier to measure so the torque should be more accurate. If the joint has a high friction coefficient the bolt advances less smoothly. The angle can be difficult to measure, so the torque should be less accurate
Test bench	The test bench / mounting surface must be solid. Any movement in the test bench / mounting surface will be seen as angle turned by the bolt, so a false reading could be taken.
Handle deflection	To be most effective the angle measuring device is often mounded at the end of the tool handle, but any deflection (bending) in the wrench handle results in an angle being measured without the joint moving.
Speed of application	Many torque instruments and tools use an electronic gyroscope to measure angle; these often require a minimum speed of angle change to work (typically 1 degree per second). If the wrench is moved too slowly, the angle will not be measured correctly.

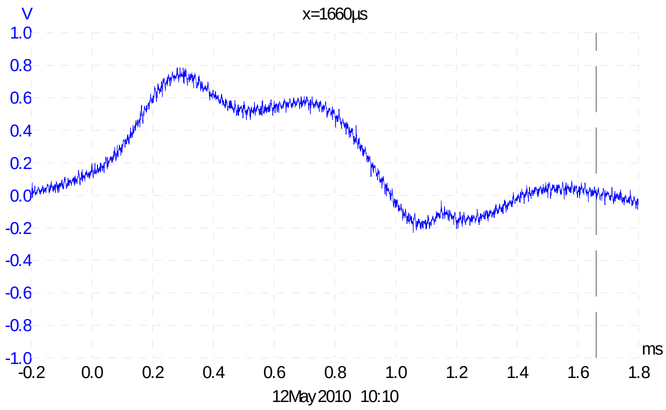
TIP. Verify the "move on" or "just move" mode works on your fastener.

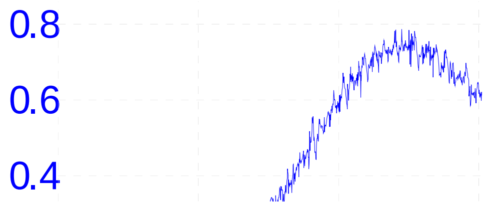
Only the electronic torque wrench and test fastener are required.
1. Tighten a typical bolt using the wrench (in Peak mode).
2. Use "move on" or "just move" mode to measure the fastener.
3. Repeat throughout the full range of the wrench / fastener.

Appendix D – Affect of adding items between impulse tool & joint

When setting up impulse tools, it is very important to use the same extensions and adapters that will be used on the job. If different adaptors are used, the applied torque to the job may be change.

Example of adding an adaptor:
The transducer signal waveform is analysed, so the peak voltage (torque) can be monitored; see below:





An adaptor or universal joint (shown above) can be added between the impulse tool and the joint. The graph can be re-measured. In a sample test for both the adaptor and universal joint the torque signal changed from 50N·m to 40N·m. Both the undo & redo torque values are less with the adaptor or universal joint fitted. This test was repeatable.

As a quick check, if the tightened bolt position is marked, it is easy to identify that adding or removing an adaptor or rotary has resulted in the same bolt position being achieved.

TIP.
1. If adaptors have to be used, use the smallest / lightest possible.
2. If a rotary transducer is used, select the smallest model able to measure the task.
3. If a rotary transducer is used, ensure the rotary transducer body is firmly held.

Appendix E – Terms used

Term	Meaning
(hydraulic) impulse tool	Powered assembly tool for tightening threaded fasteners, which applies torque to a fastener in discontinuous increments through a hydraulic impulse unit.
Torque rate	Increase in torque with angular displacement while driving a fastener in a threaded joint. A low torque rate is often called a “soft joint”. A high torque rate is often called a “hard joint”.
Redo torque	Peak torque to retighten a fastener to a known point.
Undo torque	Peak torque to undo a fastener.
Filter	Device to allow or stop different frequencies of a signal, see Appendix D.