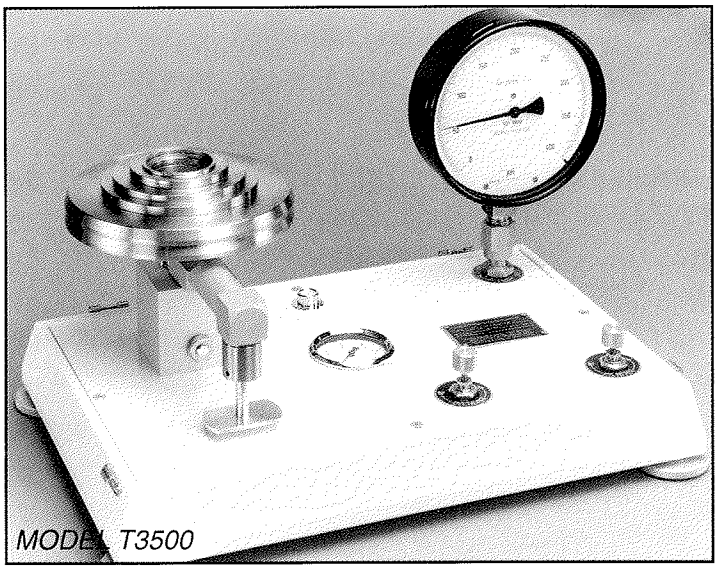
USERS HANDBOOK
Pneumatic Deadweight Testers

1.0 General Information

Deadweight Testers are the primary standard for pressure measurement. Utilising the well-proven Piston/Gauge system, consisting of a vertically mounted precision lapped Piston and Cylinder assembly, accurately calibrated weight masses (FORCE) are loaded on the Piston (AREA) which rises freely within its Cylinder. These Weights balance the upward force created by the pressure within the system.

$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}}$$

Each Weight is marked with the Tester serial number and the pressure measured when placed on a correctly spinning and floating Piston. The total pressure measured is the summation of the Weights plus the Piston Weight Carrier.


MODEL T3500

The Deadweight Tester has been calibrated to the Gravity, Temperature and Air Density stated on the Certificate. Equations and factors are given on the Certificate to adjust for any variations in these environmental conditions.*

Gravity varies greatly with geographic location and so will the Deadweight Tester reading. Due to the significant change in gravity throughout the world (0.5%), ensure that the Tester has either been manufactured to your local gravity or that you have applied the correction from the calibrated gravity.

Example:

Deadweight Tester calibrated gravity : 980.665 cm/s^2
(980.665 cm/s^2 is the International Standard Gravity)
Gravity at site : 981.235 cm/s^2
Indicated Pressure : 250 psi

$$\text{True Pressure} = \frac{981.235}{980.665} \times 250$$

$$= 1.0005812 \times 250$$

$$= 250.1453 \text{ psi}$$

Temperature and Air Density variations are less significant than Gravity.
Variations should be corrected for when maximum accuracy is required.

Temperature variation example:

Deadweight Tester calibrated temperature	:	20°C
Operating temperature	:	24°C
Percentage change per °C	:	0.002%
Indicated Pressure	:	250 psi

$$\text{True Pressure} = 250 + (20 - 24) \times \frac{0.002}{100} \times 250$$

$$= 250 - \frac{0.008}{100} \times 250$$

$$= 250 - 0.02$$

$$= 249.98 \text{ psi}$$

To ensure that accuracy is maintained, the Piston and Weights must be kept clean and undamaged.

* **See Ancillary Equipment, PDP 101, Section 9, Page 6.**

2.0 Supplied As Standard Equipment With Each Instrument:

Calibrated Weight Set in wooden case.
Certificate of Overall Accuracy.
Certificate of Piston Effective Area.
Computer print-out of Weight masses.
Female Adaptors: 1/8", 1/4", 3/8" & 1/2" BSP or NPT.
Cleaning Cloth (89) for Piston.
Spare Seals (53,67).

3.0 Connection To An External Pressure Source

Inlet Port (47) thread: 1/4" BSP or NPT female.

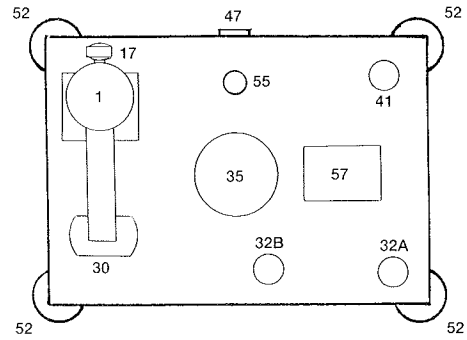
Pressure:

External air supply is connected to the Inlet Port . Ensure that the supply is both clean and dry. A compressed gas bottle (nitrogen or dry air) fitted with a pressure regulator is recommended. Factory (compressor) air-lines should only be used if a series of filters are fitted to ensure the air supply is clean and dry.

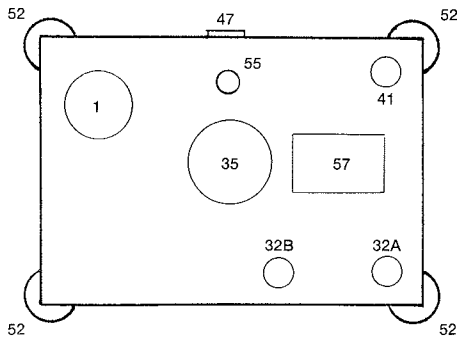
IMPORTANT: FOR SAFETY THE EXTERNAL PRESSURE SOURCE SHOULD BE REGULATED TO EITHER THE MAXIMUM RANGE OF THE DEADWEIGHT TESTER (Engraved on the Instrument Nameplate (57)) OR 10% ABOVE THE MAXIMUM PRESSURE REQUIRED, WHICHEVER IS THE LOWER.
DO NOT OVER-PRESSURISE THE DEADWEIGHT TESTER !

Vacuum:

The external Vacuum Pump is connected to the Inlet Port.



Model: T3400,T3500,T2600 (Less Items 1&17)



Model: T1400,T2300

4.0 Preparation

4.1 Find a flat, stable surface.

4.2 Level the Tester using the four Adjustable Feet (52) to the Spirit Level (55) mounted on the top plate.

4.3 Fit instrument to be tested to Test Station (41).

4.3.1 Screw the appropriate Adaptor (43) fully onto the instrument to be tested.

4.3.2 Screw assembly down **ANTI-CLOCKWISE** onto the Test Station.
Note: The internal thread in the lower half of the Adaptor is LEFT-HANDED.
Hand-tight is sufficient; ensure that the bottom face of the instrument to be tested contacts the Test Seal (42) on the Test Station.

4.3.3 To adjust position to face forward. Hold the Adaptor and unscrew the instrument to be tested **ANTI-CLOCKWISE** so that it faces forward. Hold the instrument to be tested steady whilst turning the Adaptor **ANTI-CLOCKWISE** until it pulls down onto the Test Seal.

4.3.4 To calibrate Rear Connection Gauges use a T3700 Angle Adaptor - see Ancillary Equipment, Section 9, Page 6.

IMPORTANT: ENSURE THAT ANY INSTRUMENT FITTED TO THE TEST STATION IS INTERNALLY CLEAN. - See Ancillary Equipment, T4400, Section 9, Page 6.

5.0 Operation

5.1 PRESSURE:

Note: A Monitor Gauge (35) is fitted to indicate the approximate pressure in the system.

5.1.1 Ensure both Increase and Decrease Valves (32A & 32B) are closed.
DO NOT OVERTIGHTEN, AS DAMAGE TO VALVE SEAT CAN OCCUR.

5.1.2 Select required Weights* and stack on the Piston. (*Fractional Weights: smaller increment weights are available).
The pressure measured is the total of the Weights plus the Piston Weight Carrier.

5.1.3 SLOWLY open and close Increase Valve (32A) until the Piston floats (ie not touching the top or bottom stops).
If the system is over-pressurised (Piston against top-stop) then reduce the pressure by SLOWLY opening and closing Decrease Valve (32B) until the Piston floats.

5.1.4 Rotate the weight stack clockwise.
For optional Motor Drive (only available for Models T1400 and T2300), See Section 9, Page 6.
DO NOT ROTATE WEIGHTS WHEN PISTON IS AGAINST TOP OR BOTTOM STOPS.
(When Piston is against a stop, a rubbing noise can be heard).

5.1.5 Observe reading of instrument under test.

5.1.6 For the next higher pressure point, repeat from 5.1.2.

5.1.7 To measure lower pressures, remove the necessary weights, and slowly open and close the Decrease Valve (32B), reducing the system pressure until the Piston floats, then rotate the weight stack clockwise.

5.1.8 Depressurise by SLOWLY opening and closing Decrease Valve (32B).

5.1.9 Remove weight stack.

5.2 VACUUM:

Note: Vacuum only models are fitted with a Monitor Gauge (35) to indicate the approximate vacuum in the system.

5.2.1 Ensure both Increase and Decrease Valves (32A & 32B) are closed.
DO NOT OVERTIGHTEN, AS DAMAGE TO VALVE SEAT CAN OCCUR.

5.2.2 Select required Weights and stack on the Piston.
Note: For ease of operation, slip the four smallest complete Ring Weights over the Piston and up onto the Jib Arm (11). This allows convenient access for stepping through the range.
The vacuum measured is the total of the Weights plus the Piston Weight Carrier.

5.2.3 SLOWLY open and close Increase Valve (32A) until the Piston floats (ie not touching the top or bottom stops).
If the piston rubs against the sleeve then reduce the vacuum by SLOWLY opening and closing Decrease Valve (32B) until the Piston floats.

5.2.4 Rotate the weight stack clockwise.
DO NOT ROTATE WEIGHTS WHEN PISTON IS AGAINST TOP OR BOTTOM STOPS.

5.2.5 Observe reading of instrument under test.

5.2.6 For the next higher vacuum point, repeat from 5.2.2.

5.2.7 To measure lower vacuums, remove the necessary weights, and slowly open and close the Decrease Valve (32B), reducing the vacuum in the system until the Piston floats, then rotate the weight stack clockwise.

5.2.8 Release vacuum by SLOWLY opening and closing Decrease Valve (32B).

5.2.9 Remove weight stack.

5.3 COMBINED PRESSURE & VACUUM MODELS:

WARNING: Ensure the external pressure or vacuum source connected matches the pressure or vacuum selected for calibration. Subjecting the instrument under test incorrectly with either pressure or vacuum may cause it permanent damage.

Select pressure or vacuum by using Selector Valve (17) at rear of Piston Mounting Block (10):
FULLY OUT for pressure - then operate as detailed in Section5.1.
FULLY IN for vacuum - then operate as detailed in Section 5.2.

Note: If the Selector Valve is in the vacuum position and pressure is applied to the system, then the Safety Plug (21) is ejected .
This is to limit the possible damage caused by pressurising a vacuum instrument under test.
Change external connection to vacuum and reset by pushing Safety Plug (21) and Selector Valve (17) back in.

6.0 Calibration In Different Pressure Units

Conversion Weights can be supplied to measure the existing range in any other pressure unit.

The Conversion Weight set is supplied with a special Converting Weight (marked 'CONV') which is placed on the Piston Weight Carrier. This increases the Piston Weight Carrier mass so that it now measures the value stated on the Weight in the new pressure unit. The Conversion Weight set can now be used in the same way as the Standard Weight set.

Alternative option see S700 Section 9, Page 6.

7.0 Storage And Transportation

7.1 Disconnect external pressure/vacuum source.

7.2 Replace Tester case lid, ensuring that the Hinges (62) are properly engaged, and secure with Toggle Clips (60) at sides.

7.3 For transportation tape down Adaptors (43) in Accessory Block (63).

7.4 Stack ALL the appropriate Weights on the base of the Wooden Weight Case (84), cover with lid and secure by screwing Handle (69) fully down. Ensure Handle is tight.

Vacuum:

7.5 Secure Vacuum Piston (28) against top stop, using a rubber band.

8.0 Piston Care

The Piston and Cylinder Assembly is the most critical and sensitive part of the Tester. To maintain accuracy, the Piston must always slide freely in the Cylinder.

Piston assemblies, Figures A & B (See Page 5), are specific to the following models:

Model	Assembly
T1400	A
T2300	A
T2600	B
T3400	A & B
T3500	A & B

Note: Ensure system is depressurised before attempting Piston removal, by SLOWLY opening Decrease Valve (32B).

8.1A PISTON REMOVAL - ASSEMBLY A (PRESSURE).

8.1A.1 Lift up Weight Carrier (1), and tap sharply downwards onto Cylinder (3).
Alternatively, using a small pin-head hammer and suitable flat-ended punch, tap lightly on the end of the Piston (2) through the centre of the Weight Carrier.

8.1A.2 Remove Weight Carrier.

8.1A.3 Unscrew Cylinder (3), use the dowel hole if Cylinder is tight.

8.1B PISTON REMOVAL - ASSEMBLY B (VACUUM).

8.1B.1 Unscrew Cylinder (28), use the dowel hole if Cylinder is tight, and lift out Piston/Cylinder assembly.

8.1B.2 Piston and Carrier assembly (29 & 30) can now be withdrawn from Cylinder (28).

8.2 PISTON CLEANING

IMPORTANT : NEVER TOUCH THE WORKING AREA OF A CLEAN PISTON WITH BARE FINGERS - THE NATURAL OIL IN YOUR SKIN CAN CAUSE THE PISTON AND CYLINDER ASSEMBLY TO STICK.

8.2.1 Use 'non-fluffing', non-abrasive, lint-free tissue or absorbent cloth. Hold the Piston by the larger 'head' end, or if Vacuum Piston, by the Weight Carrier (30), and rub the tissue back and forth along its length.

8.2.2 To remove all traces of contamination the Piston must be immersed in a non-filming solvent, such as Trichloroethane or Genklene.
Note: It is important to ensure that any solvent inside the Vacuum Piston (29) is removed.

8.2.3 Using a NEW tissue, clean the Piston as before, pressing hard between thumb and forefinger along the Piston's length.

8.2.4 Place Piston carefully on a NEW tissue where it will not become dirty or damaged whilst the Cylinder is cleaned.

8.3 CYLINDER CLEANING

8.3.1 Roll a tissue into a tapered rod of appropriate size. Force the tissue through the Cylinder bore by rotating. Ensure the tissue is tight so that dirt is removed. Repeat, inserting a NEW tissue from the opposite end.

8.3.2 To remove all traces of contamination the Cylinder must be immersed in a suitable solvent.

8.3.3 After removal from the solvent, repeat the cleaning process in 8.3.1.

8.4 PISTON RE-ASSEMBLY

GENERAL: The Piston must be carefully introduced into its Cylinder.
If both parts are aligned and correctly cleaned, the Piston will slide freely into the Cylinder.
NEVER FORCE THE PISTON INTO ITS CYLINDER OR DAMAGE MAY RESULT.
If resistance is felt, then re-clean either Piston/Cylinder or both.
If, after repeated cleaning, the Piston still will not slide freely within the Cylinder, then permanent damage may have occurred, in which case the complete assembly will need to be replaced or returned for evaluation.

8.4.1 **Assembly A, (Pressure):**
Hold Piston (2) by larger, 'head' end, and introduce tapered end into the threaded end of the Cylinder (3).
Place assembly vertically on a clean, hard, stable surface.
Ensure Weight Carrier (1) is clean, especially the central mounting hole, and place on tapered end of Piston.
Tap lightly using the palm of the hand to locate on the taper.

8.4.2 **Assembly B, (Vacuum):**
Hold Piston assembly by Weight Carrier (30) and introduce into the non-threaded end of Cylinder (28).

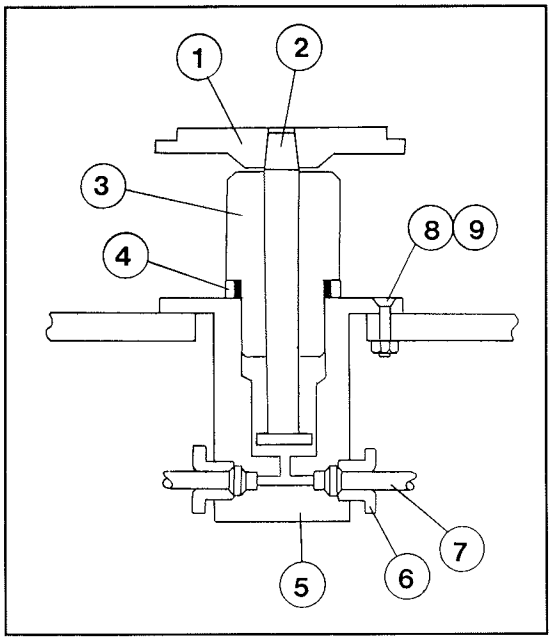
8.5 REFITTING

Screw assembly into Piston body, ensuring that the Bonded Seal (4) is clean and refitted. Do not over tighten.

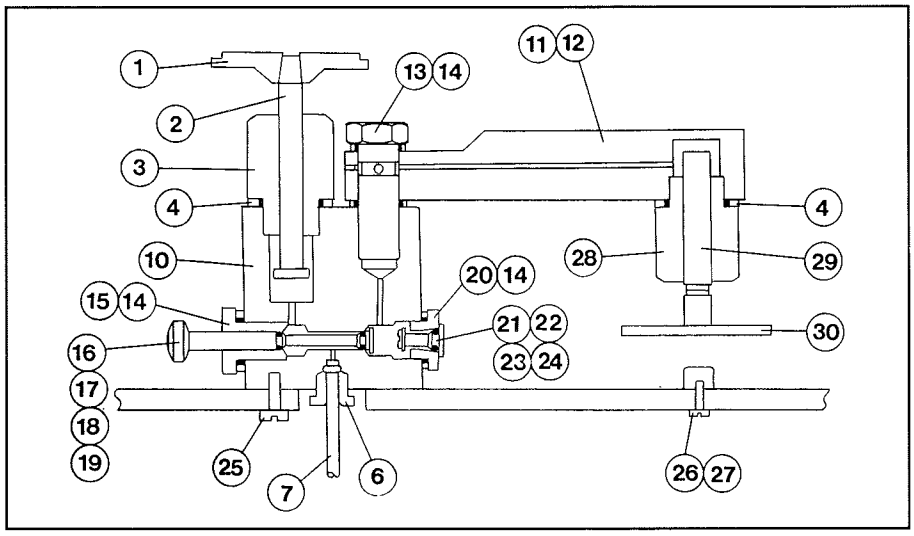
General Arrangement Drawings & Parts List - Piston Assemblies

ITEM	PART	DESCRIPTION
1	D1819	WEIGHT CARRIER
2	D4116	PISTON
3	D4117	CYLINDER
4	B1802	BONDED SEAL
5	D2402	PISTON BODY
6	B1805	MALE COUPLING
7	B1804	NYLON PIPE
8	B1808	SCREW
9	B1073	NUT
10	D2608	MOUNTING BLOCK
11	D2607	JIB
12	B2606	GRUB SCREW
13	D1210	BANJO BOLT
14	B1211	BONDED SEAL
15	D3402	GUIDE
16	B3408	SCREW
17	B3404	VALVE CAP
18	D3403	SPOOL
19	B3401	'O' RING
20	D3405	PLUG BODY
21	B3405	SAFETY PLUG
22	B3401	'O' RING
23	B1072	SCREW
24	D3407	SAFETY VALVE RETAINER
25	B1822	SCREW
26	D2609	VACUUM PISTON STOP
27	B2610	SCREW
28	D4117	CYLINDER
29	D1094	VACUUM PISTON
30	D2620	WEIGHT CARRIER

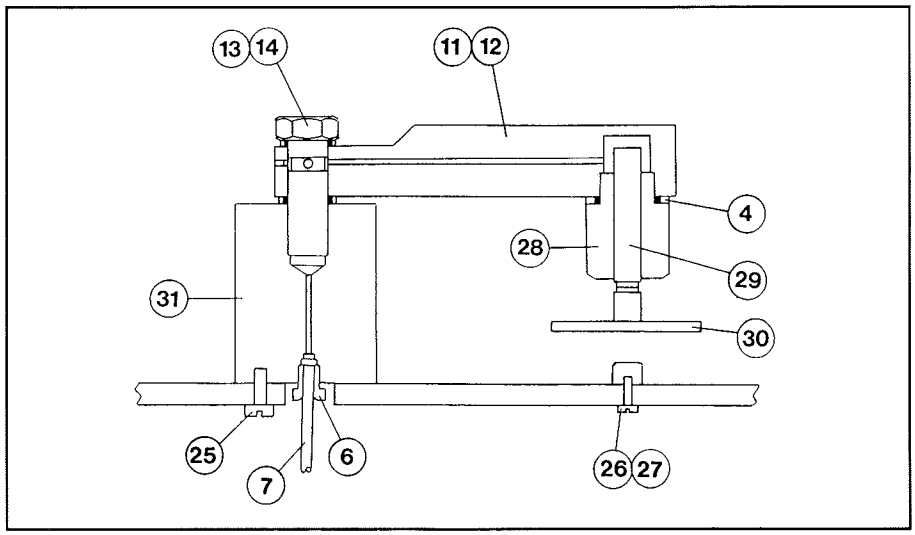
Assembly A. Model T1400, T2300



Assembly A & B. Model: T3400, T3500



Assembly B. Model: T2600



9.0 Ancillary Equipment

If you require further information on any of the following equipment, please contact your local agent.

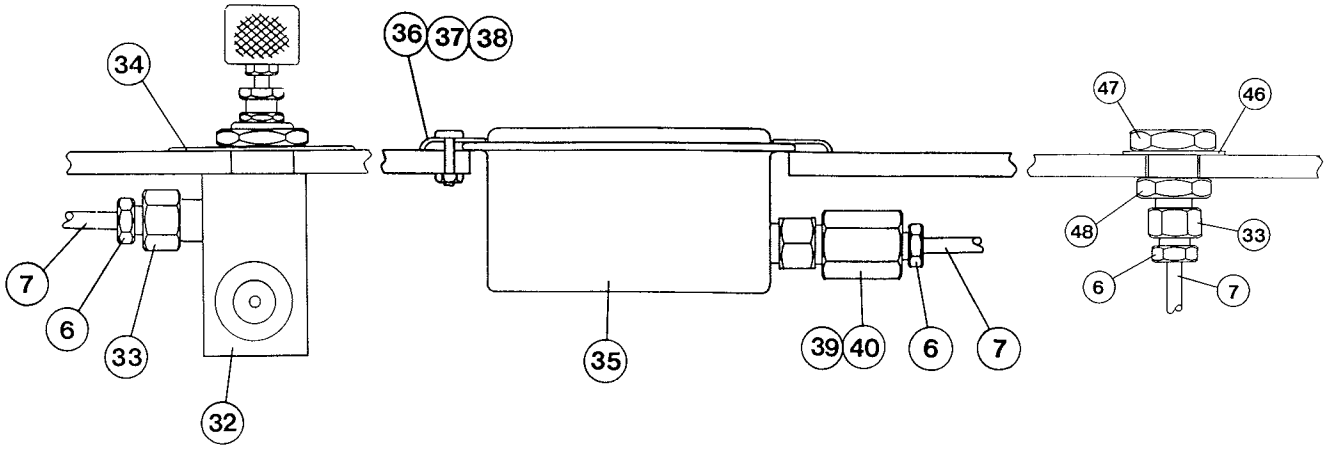
S700 SERIES CALIBRATION SOFTWARE
User friendly, menu driven, DOS based calibration software designed specifically for primary pressure standards, Deadweight Testers. This software has been developed as a flexible working tool to make pressure calibrations quicker, easier and more accurate. The software calculates which weights are required to generate a specific pressure. The programme can also calculate the pressure given the weights and piston used. The software will work in an unlimited number of pressure units, regardless of the pressure unit the Deadweight Tester has been manufactured to. You can store details on as many Deadweight Testers as required. The software generates calibration certificates which can be either printed or stored.

T4400 DIRT/MOISTURE TRAP
Prevents the instrument under test from contaminating the sensitive Deadweight Tester system. The unit is mounted directly onto the Test Station. Any particles or moisture present are trapped and can be seen through the transparent body.

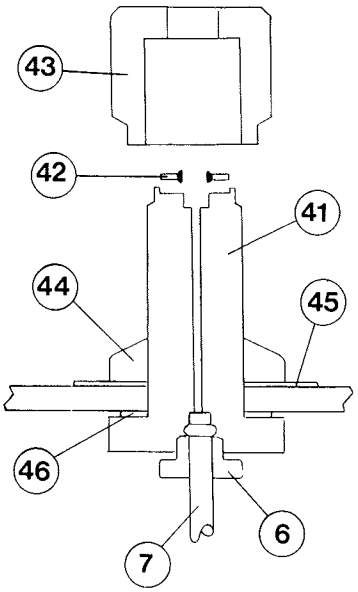
T3700 ANGLE ADAPTOR
To calibrate rear/back Connection Gauges in their correct position, an Angle Adaptor must be used. The Angle Adaptor fits directly onto the Test Station, converting it through 90 degrees, allowing the same Adaptors to be used.

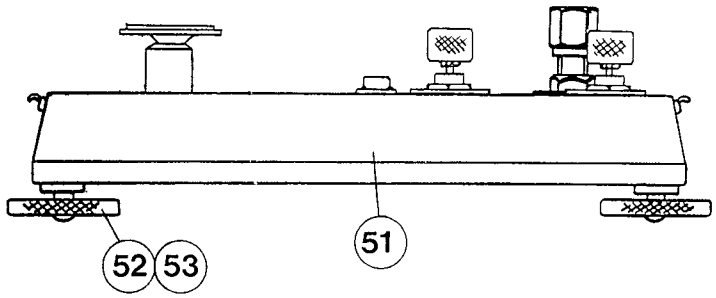
T4600 POINTER REMOVER/PUNCH
To remove and refit the pointer of a Pressure Gauge. This two-in-one tool has a spring-loaded plunger to quickly and consistently refit the pointer.

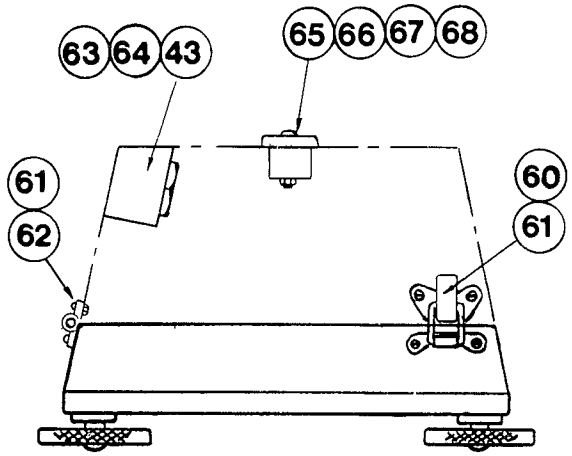
General Arrangement Drawings & Parts List

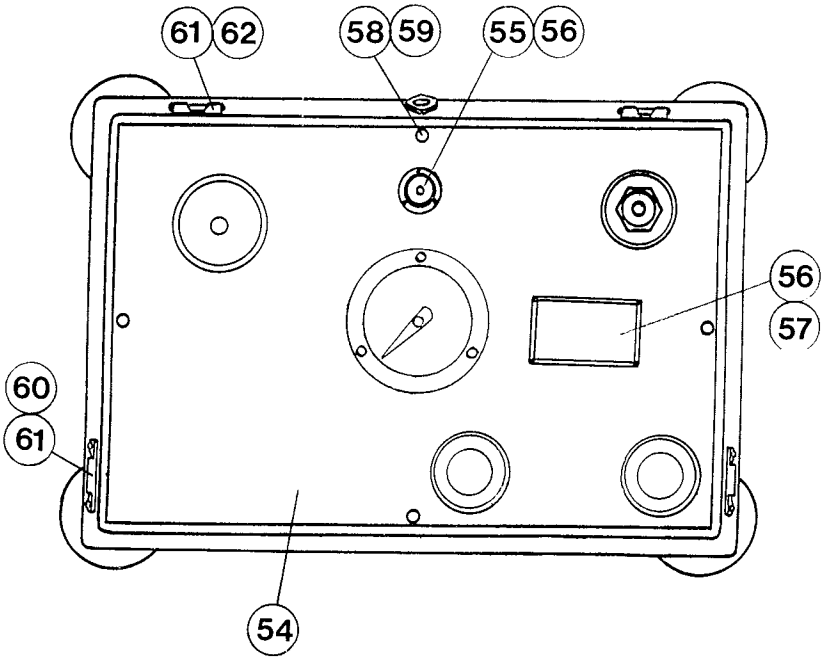


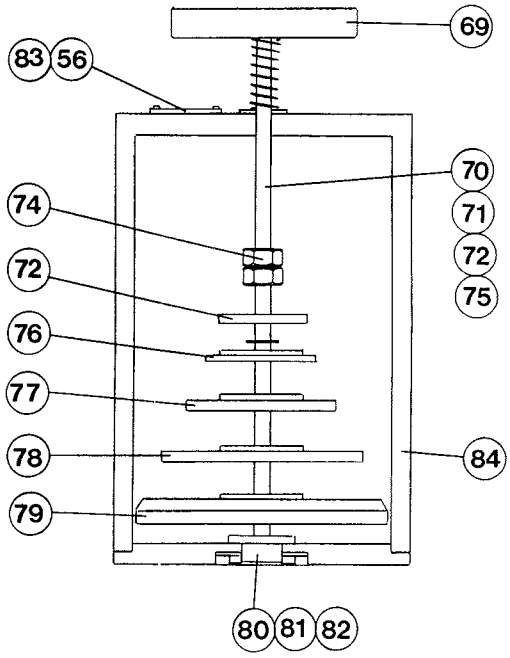
ITEM	PART	DESCRIPTION
31	D2608V	VACUUM MOUNTING BLOCK
32	T1700	NEEDLE VALVE
33	B1806	COUPLING
34	D1404	LABEL: INCREASE/DECREASE
35	B1403	MONITOR GAUGE
36	B1403A	MOUNTING RING
37	B1410	SCREW
38	B1073	NUT
39	D1409	GAUGE ADAPTOR
40	B1411	SEAL
41	D1401	TEST STATION
42	B1066	TEST SEAL
43	D1018	ADAPTOR
44	D1039	DOME NUT
45	D1098	LABEL: HAND TIGHT ONLY
46	B1407	LOCK WASHER
47	D1405	INLET PORT
48	B1807	LOCKNUT
49	B1116	TEE ADAPTOR (NOT ILLUSTRATED)
50	B2416	CROSS ADAPTOR (NOT ILLUSTRATED)











ITEM	PART	DESCRIPTION
51	D1007G	CASE
52	B1048	FOOT
53	B1047	STUD
54	D1909	TOP PLATE
55	B1045	SPIRIT LEVEL
56	B1044	SCREW
57	D1035	NAMEPLATE
58	B1086	SCREW
59	B1082	CAPTIVE NUT
60	B1076	TOGGLE CLIP
61	B1097	RIVET
62	B1077	HINGE
63	D4113	ACCESSORY BLOCK
64	B4114	SPARES BOTTLE
65	B1078	STRAP HANDLE
66	D1836	SUPPORT BAR
67	B1075	SCREW
68	B1081	NUT
69	D1058	HANDLE
70	B1834	SPRING

ITEM	PART	DESCRIPTION
71	B1835	WASHER
72	D1057	WEIGHT RETAINER
73	D1060	STUD
74	B1833	LOCKNUT
75	B1061	CIRCLIP
76	D1008	WEIGHT (PRESSURE)
77	D1009	WEIGHT (PRESSURE)
78	D1010	WEIGHT (PRESSURE)
79	D1011	WEIGHT (PRESSURE)
80	D1056	LOCATING STAND
81	B1083	WASHER
82	B1063	LOCKNUT
83	B1036	NAMEPLATE
84	D1079	WEIGHT CASE
PARTS NOT ILLUSTRATED:		
85	D2613	WEIGHT (VACUUM)
86	D2614	WEIGHT (VACUUM)
87	D2615	WEIGHT (VACUUM)
88	D2423	FRACTIONAL WEIGHTS (VACUUM)
89	B2427	CLEANING CLOTH

When ordering parts, always quote Tester Serial Number.

11.0 Fault Finding

11.1 POOR PISTON SPIN/SENSITIVITY

IF PISTON IS NOT FREE, DO NOT ROTATE AS DAMAGE MAY OCCUR, DISMANTLE AND CLEAN - SEE SECTION 8, PAGE 4.

11.1.1 If the Piston 'squeaks' when rotated, it must be cleaned.(See Section 8, Page 4).

11.1.2 The Piston and Weight Carrier alone, when floating, should spin for at least 15 seconds. If the spin time is shorter, then clean the Piston (See Section 8, Page 4).

11.1.3 Open Decrease Valve (32B). Hold the Weight Carrier and lift gently up and down. The Piston should slide freely within its Cylinder, if any resistance or a 'gritty' sensation is detected, then it must be cleaned. (See Section 8, Page 4).

11.1.4 If spin/sensitivity of a cleaned Piston deteriorates quickly then it is likely that the Deadweight Tester system is contaminated and must be completely dismantled, cleaned and rebuilt.

11.2 SYSTEM WILL NOT PRESSURISE

11.2.1 Check that Increase and Decrease Valves (32A & 32B) are closed.

11.2.2 Check for missing/damaged/dirty Test Seal (42) in Test Station (41).

11.2.3 Check that the face of the instrument under test is contacting the Test Seal (42), and the face is not dented or scored.

11.2.4 Check that external source is correctly connected and that it is fully functional.
Combined pressure and vacuum models: Check Selector Valve (17) is in the correct position.

11.2.5 Check that instrument under test is not leaking.

11.2.6 Check system for leaks by brushing soap solution onto joints and continually pressurising. The soap solution will bubble at the point of leakage. Replace Seal/Part, ensuring that sealing faces are clean and undamaged when re-assembling.
Do not put soap solution on Piston, as air will always be leaking between Piston and Cylinder.
Wipe away ALL traces of soap solution immediately after test. Prolonged soaking may cause certain parts to corrode.

11.3 PISTON DROPS QUICKLY

The Piston will always drop slowly due to a small leak between the Piston and Cylinder. This drop rate will never be so quick that a stable reading cannot be made. If a stable reading cannot be made then check Section 11.2.

12.0 Overhaul And Recertification

The Deadweight Tester's accuracy depends primarily on the effective area of the Piston and the mass of the Weights.

The Deadweight Tester will require periodic recertification, the frequency of which is dependent on use. An approximate guide is as follows:-

(i) High accuracy on-site use, recertify annually or sooner.
(ii) Harsh, rough on-site use, recertify annually or sooner.
(iii) High accuracy careful laboratory use, recertify every 2 to 3 years.
(iv) Low accuracy careful use, recertify every 5 years.

The Deadweight Tester should immediately be overhauled and recertified if either:-

(a) The Piston performance degrades (spin, sensitivity, drop rate).
(Ensure that the instructions in Section 8.0, Page 4, have been correctly carried out).
(b) The Weights are damaged or seriously corroded.

The recalibration frequency must ultimately be specified by the user, with reference to the above comments and any organisational or inspection authority requirements.