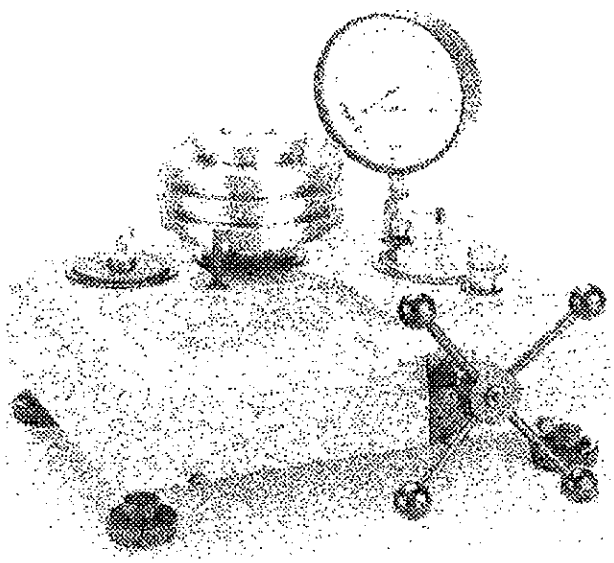
9000 SERIES
DEADWEIGHT TESTER



OPERATING MANUAL

PRESSURE INSTRUMENTS

SI-BARNET DEADWEIGHT TESTER
9000 SERIES

OPERATING MANUAL

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SI PRESSURE INSTRUMENTS

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Please read these instructions carefully prior to installing and using the Tester. The pressure built up internally during use can be extremely high. Ensure that all connections are made correctly.

DO NOT connect DWT to external pressure source.

DESCRIPTION

The 9000 Series Deadweight Tester (DWT) provides a means of testing pressure indicating instruments for calibration accuracy, oil operated and water operated units are available. The design uses the piston gauge principle in which an applied pressure within the system balances a known mass applied to a piston of known effective area. In the comparison mode the DWT can be used to compare the readings of a test instrument directly with those of a standard instrument.

The DWT (Fig.1) comprises baseplate/manifold with either one or two piston assemblies (depending on the pressure range of the particular model), two test stations (for instrument mounting), a fluid reservoir and a ram screw pressure generating mechanism. Standard accessories provided with the DWT are listed in Table 1 followed by optional accessories that are also available. Full information is provided to enable corrections to be made for pressure, temperature and gravity variations.

The ram is capable of direct pressure generation from zero to the maximum pressure rating of the DWT or 1100 bar if the DWT is functioning in the comparison mode.

The 9000 series Deadweight Tester has been designed with separate Low Pressure and High Pressure Systems built into the same unit. The changeover from Low to High Pressure is achieved automatically and is dependant on the position of the Groove in the Ram Shaft relative to the Indicating Collar (see Figure 2). A Relief Valve limits the pressure in the Deadweight Tester to approx. 40 bar until the High Pressure System is engaged, i.e. until the Groove in the Ram Shaft disappears into the indicating collar. Fluid trapped between the Low and High Pressure Systems is vented through the Relief Valve and back to the fluid reservoir.

The DWT has four adjustable feet to enable the unit to be correctly leveled. This ensures that the pistons are in the vertical plane, essential for both accuracy and reliable performance.

The 9000 Series DWT's are specified in Table 2. A motorized version of each DWT is available signified by a prefix M to the Machine Number (for example: motorized two piston machine, range 1-1100 bar is M9260/6). In a motorized machine an electric motor is used to operate the weight carrier(s) via a belt and pulley arrangement. Standard motors fitted are single phase, 220/240 volt, 50 Hz AC but alternative motors to suit different power supplies are available.

The fluid supplied for use in oil operated DWT's is one of three formulations dependent on the tester pressure range, either DW6292 (up to 350 bar), DW6293 (up to 700 bar) or DW6294 (up to 1100 bar). These fluids have been formulated to remain fluid at high pressure and ensure no corrosion to internal parts of the tester. In addition the fluids do not oxidize in air or emulsify or mix with water.

NOTE: Water operated DWT's use distilled water (01-0857).

The fluid capacity of the DWT is 325 cc (reservoir 257 cc and barrel swept volume 68 cc) and the initial supply of fluid comprises a 1 liter bottle. Further supplies are readily available from SI Pressure Instruments.

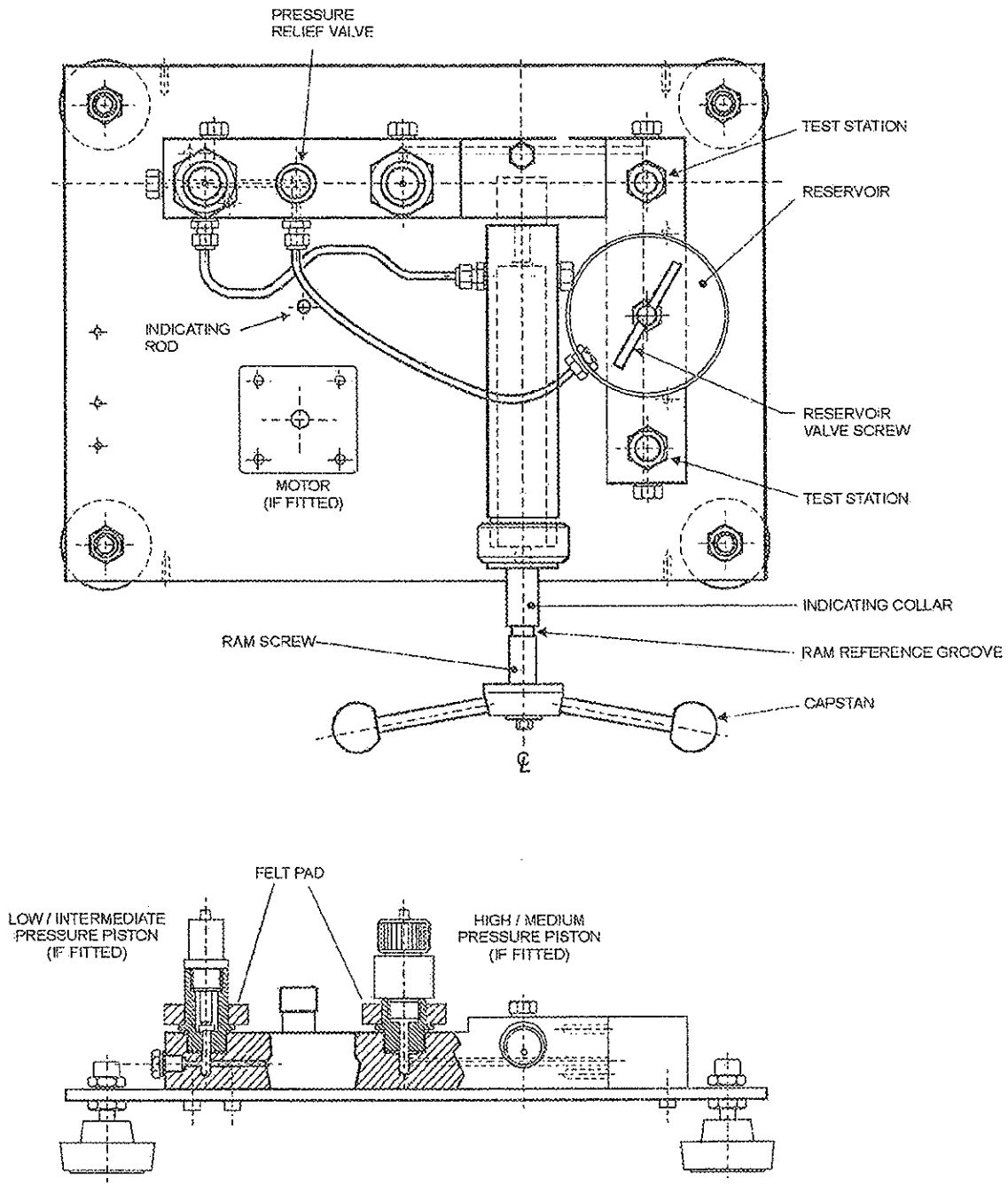


FIGURE 1
INTERNAL VIEW OF 9000 SERIES DEADWEIGHT TESTER

INSTALLATION AND PACKING

UNPACKING

Remove the DWT from the transit packing and check that all items supplied are present (see Table 1).

Filling the fluid reservoir

Fill the fluid reservoir as follows:

1. Place the DWT on a rigid clean surface with its front less than 40 mm from the edge to allow for the rotation of the capstan.
2. Unscrew and remove the reservoir valve screw and spring.
3. Remove the reservoir cover and fill the reservoir with fluid to the top of the brass nut on the side of the reservoir.

NOTE: Ensure that the fluid used is correct for the pressure rating (see paragraph seven on page 1).

4. Replace the reservoir cover.

PRIMING

Prime the fluid system as follows:

1. Replace the reservoir valve screw and spring and firmly tighten, then unscrew four full turns.
2. Check that blanking plugs are fitted to the Test Stations.
3. Screw the capstan fully out (counterclockwise) and check that the fluid level in the reservoir drops.
4. Screw the capstan fully in (clockwise); this causes the fluid to be returned to the reservoir.
5. Repeat steps 3 and 4 until little air is present in the returned fluid.
6. Screw the capstan fully out.
7. Screw the reservoir valve screw fully clockwise and firmly tighten.

LEVELING

Set the equipment level as follows:

1. Using the capstan, pressurize the system until a weight carrier floats approximately midway between the red marks on the indicator rod.
2. Place the spirit level on the floating weight carrier and level the DWT by means of the four adjustable feet. The bubble must be in the center of the small black circle and the DWT must not rock.

TABLE 1 - ACCESSORIES

STANDARD ACCESSORIES

Certificate of Accuracy of Deadweight Tester.

Certificate(s) of Test and Inspection for Deadweight Tester piston(s)

Operating Manual (this manual).

Operating Fluid

Wooden Carrying Case containing:
- Set of Stainless Steel Weights (see Table 2).
- Set of Adaptors, 1/8", 1/4", 3/8", 1/2" BSP Female
- Right angle conversion adaptor for above
- Set of Seals
- Spirit Level
- Dust Cover

OPTIONAL ACCESSORIES

Conversion Weight Set:
Converts any specified Deadweight Tester for use with any alternative unit of pressure.

Fractional Weight Set:
Allows smaller increments of pressure to be generated and measured.

"Oxytester":
Connects directly to a 9000 Series Deadweight Tester and provides a flexible baffle between the Deadweight Tester fluid and the fluid in the instrument under test. Maximum pressure 550 bar/8000 psi.

TABLE 2 - 9000 SERIES DEADWEIGHT TESTERS

Machine Number	Water Unit	Number of Pistons	Pressure Range			Number of Weights Per Set
			lbf/in²	Kgf/cm²	bar	
9120/4	•	1	10-500			12
9120/5	•	1		1-35		13
9120/6	•	1			1-35	13
9130/4	•	1	20-1000			12
9130/5	•	1		2-75		14
9130/6	•	1			2-75	14
9150/4	•	1	50-5000			12
9150/5	•	1		5-350		13
9150/6	•	1			5-350	13
9170/4	•	1	100-10000			12
9170/5	•	1		10-700		13
9170/6	•	1			10-700	13
9180/4		1	100-16000			15
9180/5		1		10-1100		17
9180/6		1			10-1100	17
9230/4	•	2	10-5000			12
9230/5	•	2		1-350		13
9230/6	•	2			1-350	13
9250/4	•	2	10-10000			12
9250/5	•	2		1-700		13
9250/6	•	2			1-700	13
9260/4		2	10-16000			15
9260/5		2		1-1100		17
9260/6		2			1-1100	17

Motorized units are prefixed with "M" e.g. M9250-4. Water operated units are suffixed with "W" e.g. 9250-4-W.

OPERATION

GENERAL

Before commencing operation, identify tester model and relevant operating mode (Low pressure or High pressure) from Table 3. Note that comparison mode is applicable to all models.

Rotation of the weight stack is either manual, where no motor is fitted (no prefix M to tester number), or motorized where a motor is fitted (prefix M before tester number). Motorized testers must only be operated by power and not manually because manual operation could damage the drive pins and cause inaccuracy during subsequent use.

For manual rotation proceed as follows:

1. Grasp the weight stack firmly in both hands.
2. Turn the weight stack clockwise (viewed from above) at a speed of approximately 1 revolution per second, taking care to avoid trapping the hands between the weights and the test instrument.

Commencing and ending rotation on the motorized tester entails setting the motor switch to 'ON' and 'OFF' respectively. A full weight stack may require light manual assistance to commence rotation. To drive the weight stack on the Deadweight Tester at a constant speed of approximately 70 rpm, a synchronous motor has been selected for both it's quiet operation and low heat output characteristics.

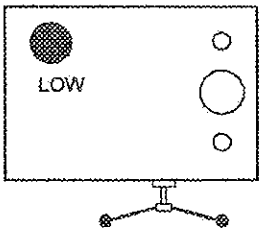
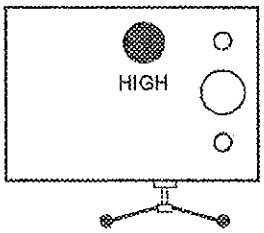
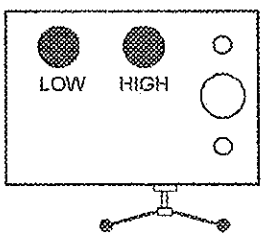
After partially pressurizing the system, the motor should be switched 'ON' to initiate clockwise rotation of the weights.

Manual assistance may be required to overcome inertia, especially with a full weight stack.

It is possible that a 'chattering' noise may emanate from a stalled motor due to rotor oscillation between poles; this is NOT detrimental to the motor but it' occurrence during testing may indicate a 'bottoming' of the weight stack. Continuous rotation of the weight stack at its bottom position should be avoided.

NOTE: Before connecting motorized equipment to power supply, ensure that voltage is as stated by supply inlet.

TABLE 3
PRESSURE MODE INDENTIFICATION

Machine Type	Pressure Range bar / kgf/cm²	Pressure Range lbf/in²	Operating Mode (pressure)
	1-35 2-75	10-500 20-1000	LOW
	5-350 10-700 10-1100	50-5000 100-10000 100-16000	HIGH
	1-35 5-350 10-700 10-1100	10-500 50-5000 100-10000 100-16000	LOW HIGH

LOW PRESSURE PISTON MODE

Proceed to operate in this mode as follows:

1. Ensure no pressure is in the system by opening the reservoir valve screw 4 turns counterclockwise from the fully closed position.
2. Fit the instrument under test to a Test Station using the appropriate adaptor. Screw the adaptor to the test station fully clockwise (finger tight only).
3. Bleed air from the system by screwing the capstan fully 'out' (counterclockwise) and then fully 'in' (clockwise) and then fully 'out' again. Repeat if necessary until no air appears in the fluid reservoir.
4. Close the reservoir valve screw (fully clockwise).
5. Place the appropriate weights onto the weight carrier.
6. Apply pressure by turning the capstan clockwise until the weight floats with the lower edge of the first weight aligned between the upper and lower red marks on the indicator rod (see Figure 3).
7. Rotate the weight stack, see 'General Operation' (if motorized, set motor switch to 'ON').
8. With the weights floating and spinning, the pressure generated in the system will be the pressure marked on the weights plus the pressure marked on the weight carrier.

NOTE: Ensure that the ram indicator groove is fully visible throughout the test (see Figure 2) (i.e. do not engage the high pressure system).

9. Stop the weight stack spinning (if motorized, set the motor switch to 'OFF') before adding or removing weights.
10. Increase pressure by screwing the capstan in (clockwise).
11. Reduce pressure by screwing the capstan out (counterclockwise).
12. To reduce pressure to zero, screw the capstan fully out (counterclockwise).
13. Unscrew the reservoir valve four turns counterclockwise.
14. Remove weights from weight carrier.
15. Remove the instrument under test.
16. Refit the blanking plug to the test station.

HIGH PRESSURE PISTON MODE

Proceed to operate in this mode (right hand piston if fitted) as follows:

1. Ensure no pressure is in the system by opening the reservoir valve screw 4 turns counterclockwise from the fully closed position.
2. Remove low pressure weight carrier if using double piston model.
3. Fit the instrument under test to a Test Station using the appropriate adaptor. Screw the adaptor to the Test Station fully clockwise (finger tight only).
4. Bleed air from the system by screwing the capstan fully 'out' (counterclockwise) and then fully 'in' (clockwise) and then fully 'out' again. Repeat if necessary until no air appears in the fluid reservoir.
5. Close reservoir valve screw (fully clockwise).
6. Place appropriate weights onto the weight carrier.
7. Apply pressure by turning the capstan clockwise until the weight stack floats with the lower edge of the first weight aligned between the upper and lower red marks on the indicator rod (see Figure 3).
8. Rotate the weight stack (if motorized, set the motor switch to 'ON').
9. With the weights floating and spinning, the pressure generated in the system will be the pressure marked on the weights plus the pressure marked on the weight carrier.

NOTE: For pressure above 40 bar (approx.) ensure that the Ram Indicator Groove is not visible (see Figure 2) i.e. engage High Pressure System.

10. Stop the weight stack spinning (if motorized, set motor switch to 'OFF') before adding or removing weights.
11. Increase pressure by screwing capstan in (clockwise).
12. Reduce pressure by screwing capstan out (counterclockwise).
13. To reduce pressure to zero, screw capstan fully out (counterclockwise).
14. Unscrew reservoir valve four turns counterclockwise.
15. Remove weights from weight carrier.
16. Remove the instrument under test.
17. Refit blanking plug to test station.
18. Replace low pressure weight carrier if any (ensure correct location).
19. Turn off power at supply if motorized.

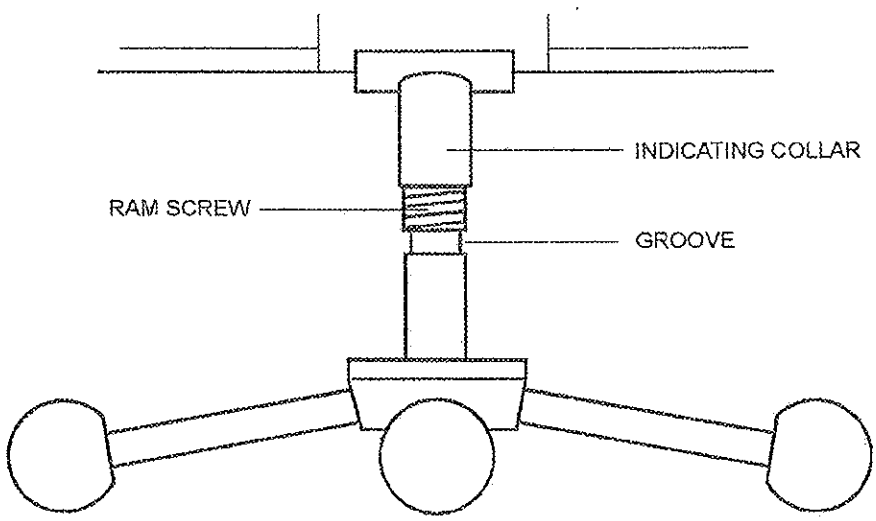


FIGURE 2
RAM REFERENCE GROOVE (LOW PRESSURE POSITION)

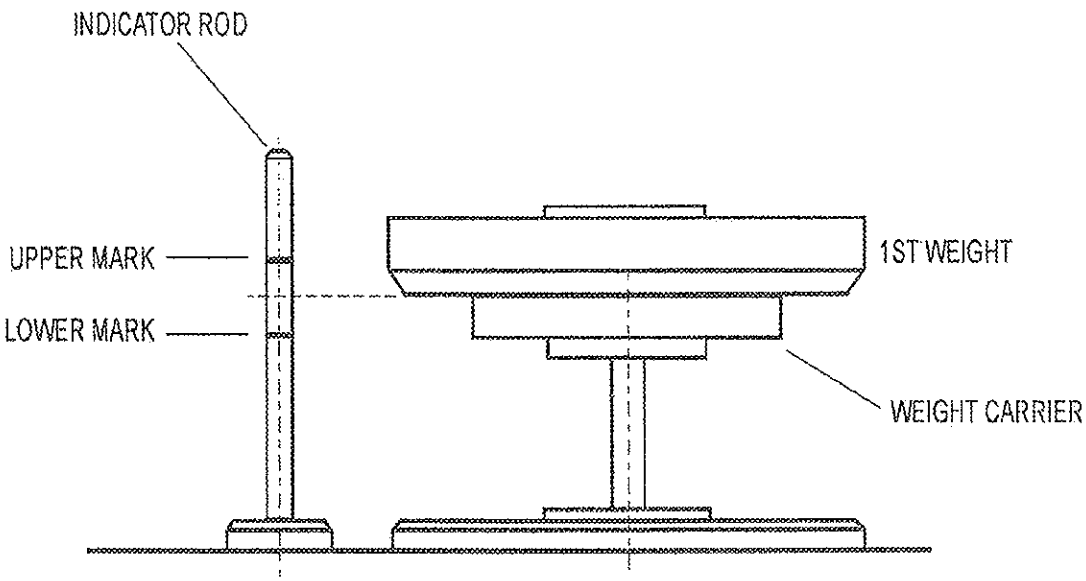


FIGURE 3
POSITION OF FLOATING WEIGHTS FOR CORRECT READING

PRESSURE COMPARISON MODE

Proceed to operate in this mode (all models) as follows:

1. Ensure no pressure is in the system by opening the reservoir valve screw 4 turns counterclockwise from the fully closed position.
2. Remove the blanking plugs from the test stations.
3. Fit the standard instrument and the instrument under test to the test stations using the appropriate adaptors. Screw fully clockwise, finger tight only.
4. Bleed air from the system by screwing the capstan fully 'out' (counterclockwise) and then fully 'in' (clockwise) and then fully 'out' again. Repeat if necessary until no air appears in the fluid reservoir.
5. Close reservoir valve screw (fully clockwise).
6. Screw the capstan in (clockwise) to increase the pressure to the required value.
7. On completion of comparison tests reduce pressure to zero by screwing the capstan fully out (counterclockwise).
8. Unscrew the reservoir valve screw four turns.
9. Remove the instruments and refit the blanking plugs.

DO'S AND DONT'S FOR OPERATING DEADWEIGHT TESTERS

Dont's

DO NOT remove low pressure insert or high pressure carrier from pistons.

DO NOT use spanners on "quick-fit" adaptors (finger tight all the way down is all that is required).

DO NOT touch piston operating surfaces (they could become damaged).

DO NOT remove cover.

DO NOT transport Deadweight Tester with fluid in the system.

DO NOT rotate weight stack in the top or bottom position, especially by motor.

DO NOT allow fluid level to fall below the recommended minimum level.

Do's

Do have the Deadweight Tester and weight set recalibrated at regular intervals.

Do ensure that the 'floating' weight stack is level in both planes.

Change fluid regularly to flush out any contaminants.

PRESSURE CORRECTIONS

Pressure correction is required for high accuracy work and is due to the effects of pressure on the PCU assembly during operation. By reference to the certificate of calibration provided the actual pressure in the system can be obtained. All values relate to the environmental conditions stated on the certificate.

The pressure in the system when the carrier is loaded with major weights can be read directly from the second column of the certificate.

The pressure in the system when the carrier is loaded with incremental weights is given together with the pressure in the system when the carrier is loaded with major and incremental weights. From these values, assuming effects are linear, the incremental weight corrections over the range may be calculated.

If the DWT is located at a position where the values of the gravitational acceleration and temperature of the operation are the same as those values specified for calibration, then the Actual Pressure is fully corrected. If the DWT is used under different conditions then further correction is necessary (see Figure 4). The reference level is specified on the certificate.

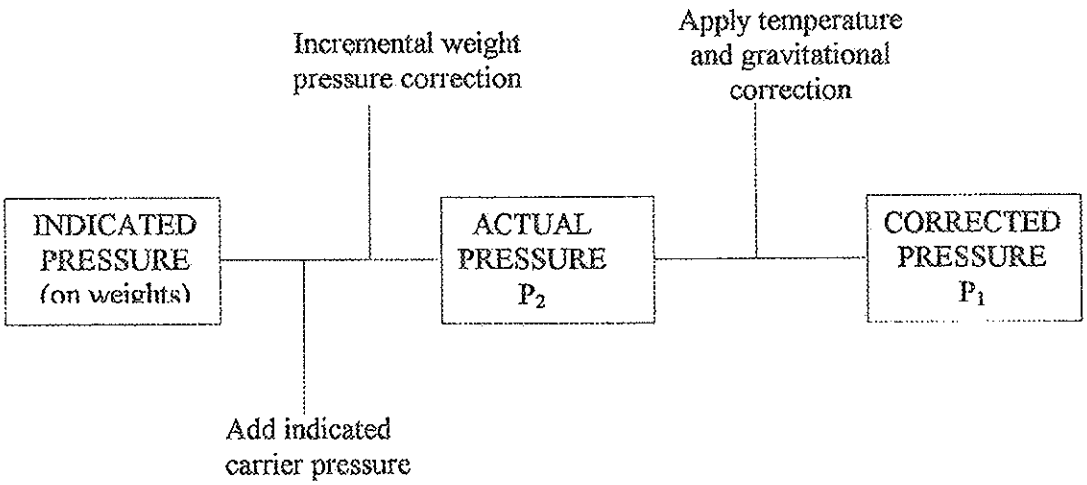


FIGURE 4
PRESSURE CORRECTIONS

TEMPERATURE AND GRAVITY CORRECTIONS

Deadweight testers are manufactured to give an accurate pressure reference at the specified temperature and gravity values indicated on the certificates. The following Standard Values are applied during calibration unless otherwise requested during manufacture (see Certificate).

Standard Gravitational acceleration (G)	9.80665 m/s²
Standard Temperature (T)	20°C

$$p_1 = p_2 \left(1 + \alpha \left(T - t\right)\right)\frac{g}{G}$$

Where:

P_1	=	Corrected Pressure
P_2	=	ACTUAL PRESSURE
α	=	Coefficient of Linear Expansion (The value for a specific piston / cylinder assembly (PCU) is shown on the Calibration Certificate)
T	=	DWT calibrated temperature (°C)
t	=	Temperature at position of DWT (°C)
g	=	Gravitational acceleration at position of DWT
G	=	DWT calibrated gravitational acceleration

The value of gravitational acceleration (g) varies with latitude, height above sea level and geological conditions at the location of the DWT. When the gravitational acceleration varies from that for which the DWT was calibrated, the above correction must be made. The local value of gravitational acceleration (g) can be obtained as follows:

Data from the appropriate geophysical authority

Approximated from the Nomogram (Figure 5).

Calculated from the formula:

$$g = 9.7803184\left(1 + 0.0053024\sin^2 L - 0.0000059\sin^2 2L\right) - 0.0000038086\,H$$

Where

L = geographical latitude, H = height above sea level in meters and units of g are m/sec²

HEIGHT CORRECTIONS

Tests carried out at locations other than the test stations may require corrections for fluid heights. The pressure exerted by a column of fluid 25.4mm high will not exceed 0.0025 bar using the recommended fluids.

Explanation of Nomogram

A straight line passing through the known values of altitude (H) and latitude (L) of the site of the DWT, when extended to scale 'g', will indicate the approximate value of 'g'.

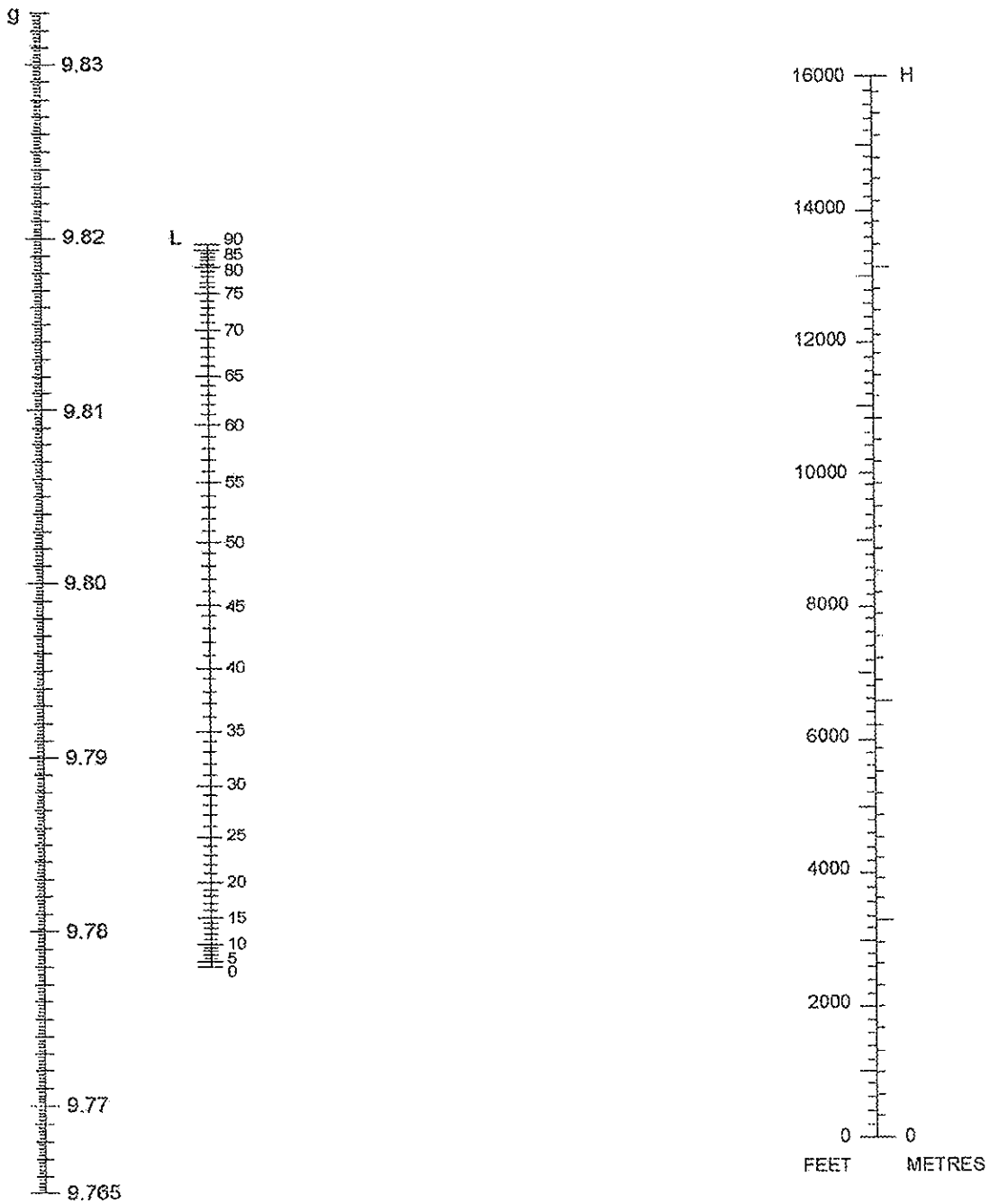


FIGURE 5
NOMOGRAM FOR FINDING THE VALUE OF 'g' FROM ALTITUDE AND LATITUDE.

MAINTENANCE

GENERAL

The 9000 Series DWT has been designed to require minimal maintenance. Routine maintenance entails that the equipment is kept free from dirt and dust. The dust cover is to be fitted when the DWT is not in use.

Repair maintenance is limited to self evident replacement of seals, fluid and felt pads. In motorized DWT's the fuses and drive belts may be replaced.

USER SPARES LIST

DESCRIPTION	PART NUMBER	NO. OFF
1/8" BSP External Dowty Seal	DWSK9000	5
1/4" BSP External Dowty Seal		5
3/8" BSP External Dowty Seal		5
Spare "O" Rings for Adaptor Set		10
Felt Pads		4
For Motorized Model		
Drive Belt (Single Piston)	DWSKM9000	1
Drive Belt (Double Piston		1
Fuse		2
DWSK9000		1

NOTES: If ordering supplies of fluid, ensure that correct type is ordered for DWT pressure range. If fluid contacts skin, allergic reaction may result. Wash using soap and water.