DHI PRESSURE STANDARDS

5301 - 5302 - 5303 - 5304

USER'S MANUAL

06/83
MANUAL #13-1

1905 West Third Street • Tempe, AZ 85281 • 602/967-1555 • TX: 592 299, DHI AZ

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ANNEXES

CHAPTER 1

PURPOSE AND OPERATING PRINCIPLE

I - 1 - PURPOSE

DH Model 5303 Pressure Standards are oil operated deadweight testers used to calibrate and test gauges, transducers and transmitters at pressures up to 20,000psi.

I - 2 - OPERATING PRINCIPAL

The key component is the mounting post which combines the primary metrological elements:

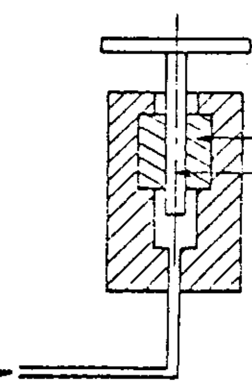
1 - The piston-cylinder which defines an effective area, A.

2 - The masses, of global value M, which act upon the piston.

The value of the pressure, P, which puts the piston into equilibrium is given by the formula:

$$P = \frac{Mg}{A}$$

g = Acceleration due to gravity



OPERATING PRINCIPAL

(Figure I - 1)

CHAPTER II

DESCRIPTION OF THE MODEL 5303

II - 1 - COMPONENT CHECK LIST

- Housing : Light alloy casting, housing all the components necessary for operation. Delivered in a wooden cabinet.

- Mass set : Total value is generally 20, 30, 40 or 80kg. The masses are supplied in a series of wooden storage cases.

- Piston-cylinder : Supplied in a carrying case with a special mounting tool.

- Standard accessories :

  - 1 Instruction manual
  - 1 Calibration certificate and technical data
  - 1 Quart sebacate
  - 1 Drive belt No. 650
  - 2 Piston travel limit pins No. 30199
  - 4 Foot rest No. 37613
  - 1 Plastic cover No. 31113
  - 1 O-ring assembly mounting tool No. 40957
  - 1 O-ring assembly for the measuring post No. 41096
  - 1 O-ring assembly for the quick connecting head No. 41087
  - 1 Gland for standard DH 20,000psi fitting No. 40966
  - 1 Plug for standard DH 20,000psi fitting No. 41009
  - 1 DH quick connector with DH standard 20,000psi fitting No. 41100
  - 1 Mass carrying bell
  - 1 Oil run-off cup No. 39509
  - 1 250 mA delayed fuse
  - 1 Power supply cord
  - 1 RTD output cable (S', S and S^2 accuracy only)

II - 2 - SUB-ASSEMBLY LOCATION WITH MANUFACTURES REFERENCE NUMBERS

The Model 5303 is made up of a housing into which the following sub-assemblies are integrated:

Center
(1) The mounting post into which the piston-cylinder is installed No. 40959 (No. 41513 for S', S and S^2 accuracy)

Upper Front Face
(2) Power on/off switch No. 527
(3) On/off indicator light No. 380627-2
(4) Reference level line

Lower Front Face
(5) Reservoir isolation valve No. 40912
(6) Piston displacement indicator No. 38576
(7) Variable volume screw press No. 40985

Top
(8) Oil reservoir cap No. 37369
(9) Quick connecting head No. 42222
(10) Bubble level No. 41468

Right Side
(11) Priming pump handle No. 41315
(12) Carrying handle No. 5000

Left Side
(12) Carrying handle No. 5000
(13) Sump purge drain-cock No. 35376

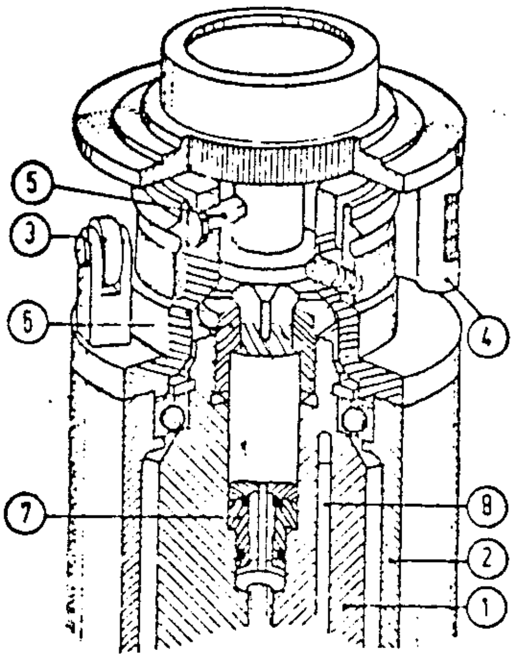
Rear
(14) Receptacle for motor power supply cable No. SLEM-23C
(15) Fuse No. 19201
(16) RTD output receptacle No. SLEM-25S (S', S and S^2 accuracy only)
(17) Oil run-off cup No. 39509 (delivered with the accessories)

Inside
(5) Reservoir isolation valve No. 40912
(7) Variable volume screw press No. 40985
(18) Oil reservoir No. 40999
(19) Priming pump No. 40992
(20) Sump No. 36816
(21) Motor for piston rotation No. 39149 (110V AC)

The housing is closed in the rear by an steel panel held by a quick disconnect pin.

II - 3 - DESCRIPTION OF THE SUB-ASSEMBLIES

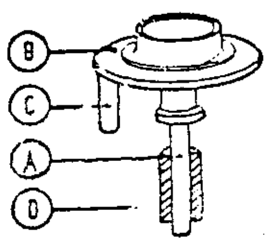
Mounting post



Function : Piston-cylinder mounting post.

Description: Stainless steel body (1) over which a pulley (2) is mounted on bearings. The pulley is rotated by the motor using a drive belt. The pulley assures piston rotation using the drive pin (3) which pushes the pin (4) on the piston plate.
(5) Piston travel limit pin
(6) Cylinder retaining nut
(7) O-ring assembly
(8) Platinum RTD (S', S and S^2 accuracy only)

Piston-cylinder

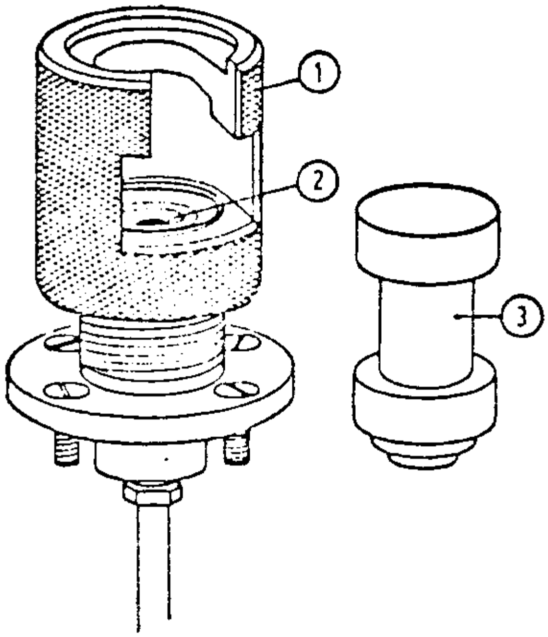


Function : Fundamental metrological element which transforms the pressure into a measurable proportional force.

Description: The piston (A) is equipped with a plate (B) on which is mounted a pin (C). The cylinder (D) is always made of tungsten carbide and the piston is made of tungsten carbide or steel.

Piston-cylinders of different effective areas are interchangeable. All pistons have the same mass (0.2kg) and all cylinders have the same external dimensions.

Quick-Connecting Head

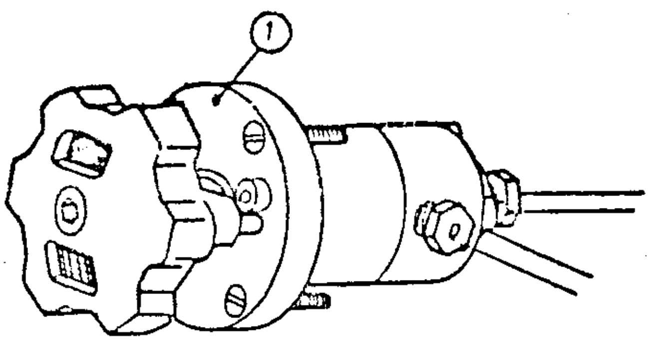


Function : Connection point to the system under test.

Description: A convenient connection which will not be damaged or wear despite many make and break operations. The knurled nut (1) tightens onto a connector (3). An O-ring assembly (2) makes the seal. The knurled nut is tightened by hand even at the highest pressures. The quick connecting head is an interchangeable sub-assembly but general maintenance requires only the replacement of the O-ring assembly.

Note: Many different connectors for the quick-connecting head are available.

Valve



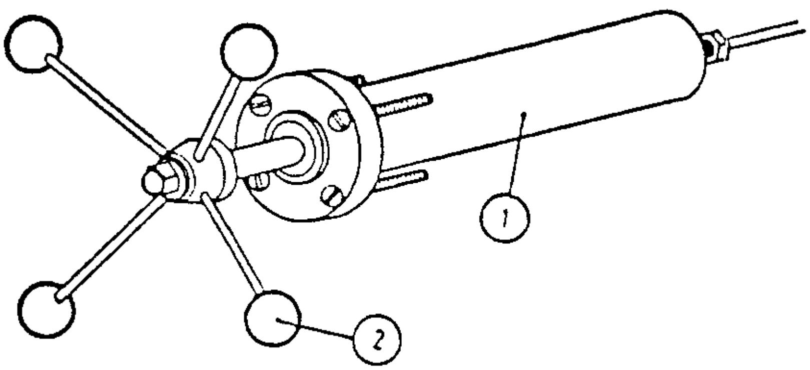
Function : To isolate one part of the hydraulic circuit from another.

Description: In the closed position, the red label on the handle is across from the white reference dot (1). A belleville spring pushes the needle onto its seat. The handle feels loose when valve is closed. The opening of the valve is progressive and made by turning the handle clock wise to compress the spring. Rotation of the handle is limited to a half turn by stops. The valve is an interchangeable sub-assembly.

Variable volume screw press

Function : Pressure generation and regulation up to 20,000psi.

Description: A cylinder (1) in which a plunger moves by turning a handle (2). Variation of volume for the entire plunger stroke is 8 cm^3 (.49 in^3).
Variation for one handle turn is 0.17 cm^3 (.01 in^3).

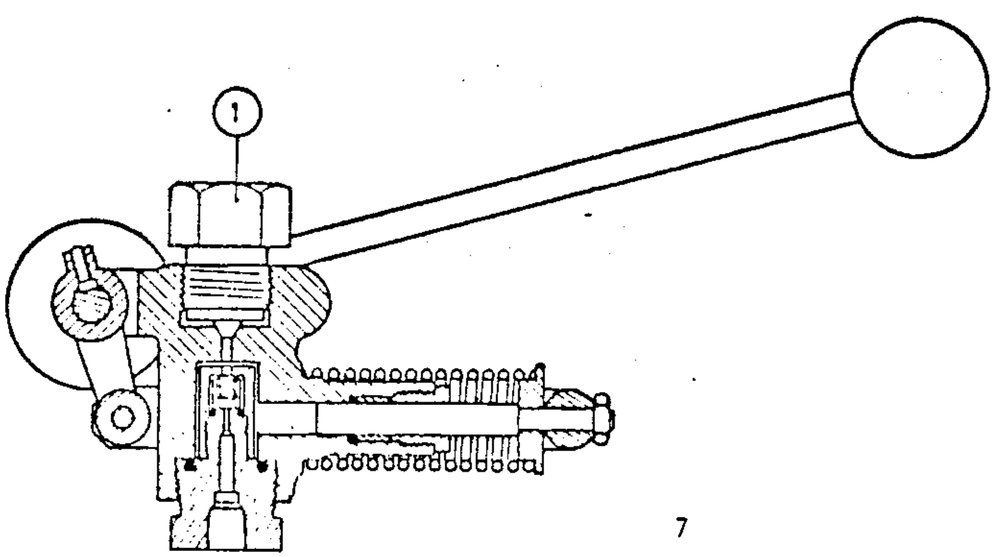


The variable volume screw press is an interchangeable sub-assembly.

Priming pump

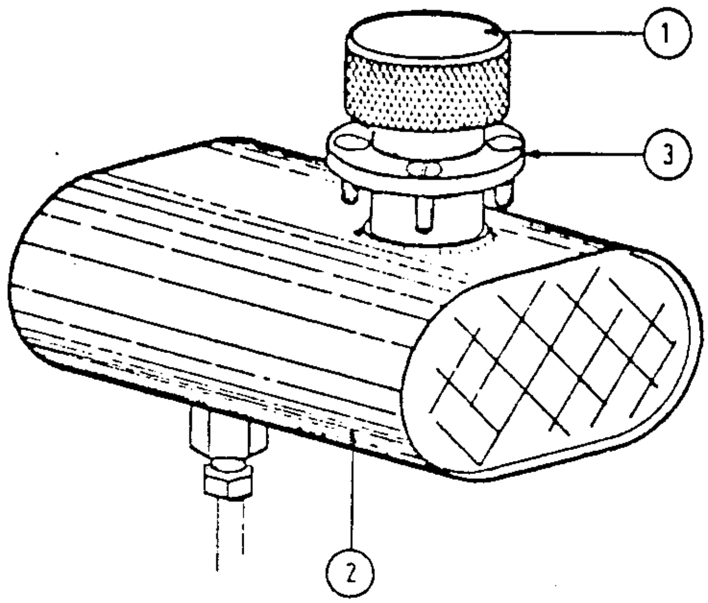
Function : To fill and prime the internal and external hydraulic circuits.

Description: Single piston pump consisting of an inlet (1) and outlet check valve. Flow for one stroke is 3.5 cm^3 (.214 in^3). The priming pump is an interchangeable sub-assembly.



Oil Reservoir

Function : Hold the pressure medium.

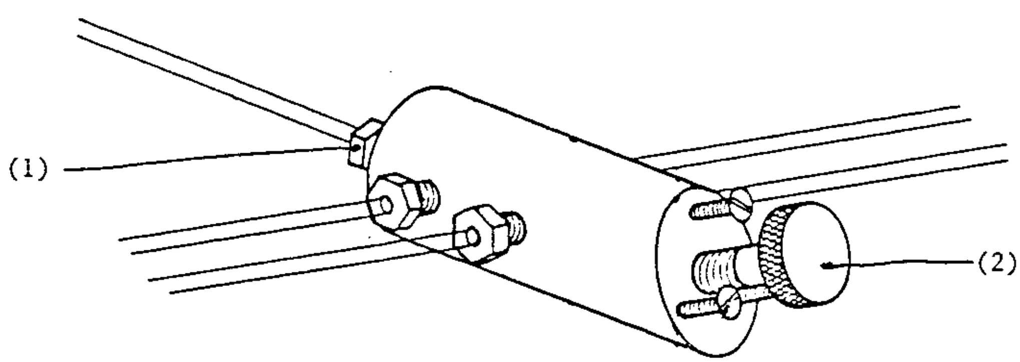


Description: Tank (2) fabricated in stainless steel. The cap (1) is equipped with an O-ring for hermetic sealing during travel and storage. The oil reservoir is an interchangeable sub-assembly.

Sump

Function : Located at the low point of the hydraulic circuit to serve as a purge point for impurities coming from the system under test. Serves as the manifold for all the tubing of the high pressure circuit.

Description: A cylinder (1) with the fittings needed for the connection of the various hydraulic lines. A drain-cock (2) allows partial or complete purge of the system. The sump is an interchangeable sub-assembly.

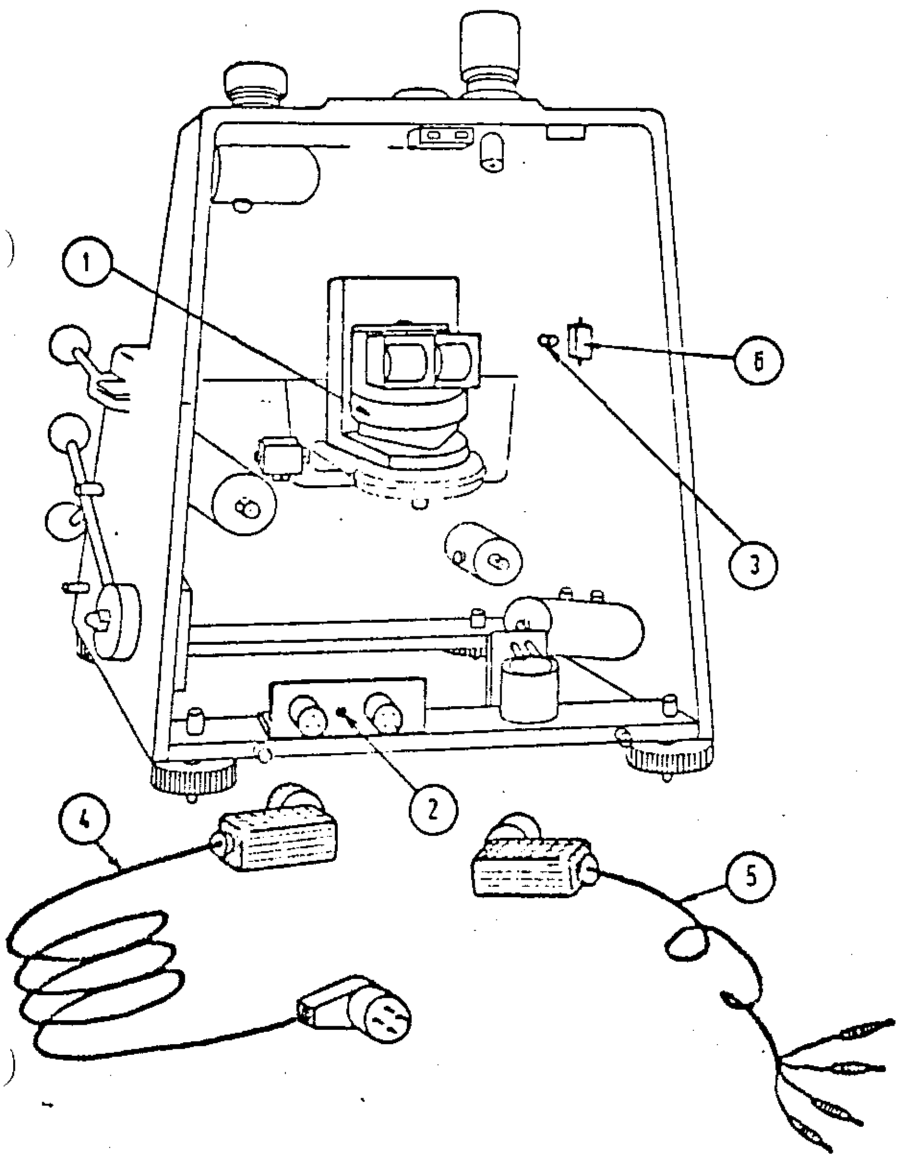


Electrical System

A) Motor

Function : For piston rotation using a drive belt and the mounting post pulley.

Description: Made up of a 30RPM squirrel cage motor (1), an on/off switch (6), an on/off indicator light (3), a fuse (2), and a 2.5 meter power supply cable (4). The motor is an interchangeable sub-assembly.

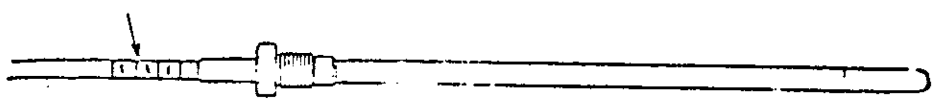


B) Temperature probe (S', S and S^2 accuracy only)

Function : Measure as well as possible the temperature of the piston-cylinder assembly.

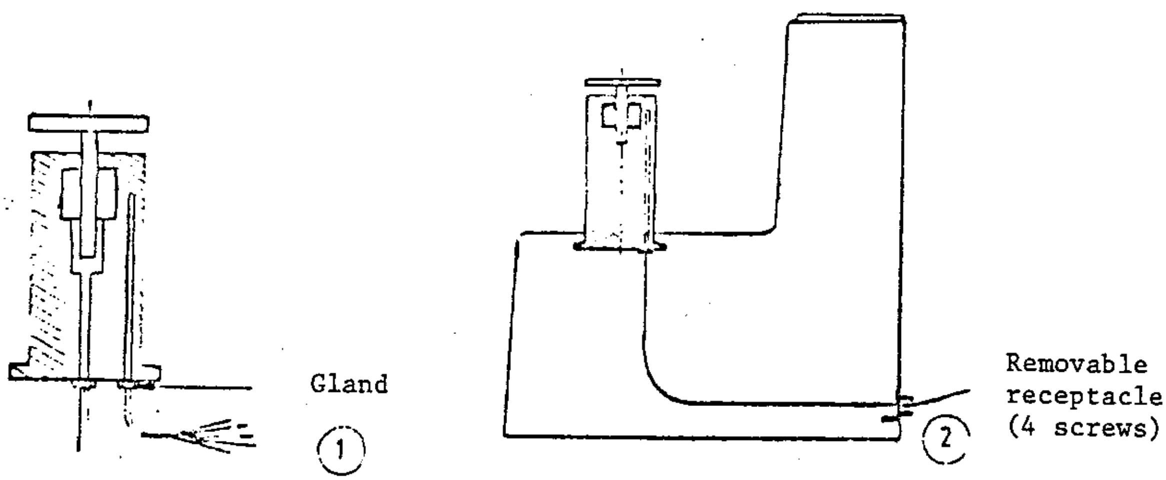
Description: Platinum RTD with 100 ohm nominal resistance at 0°C following DIN standard 43760. The 100 ohm value is given with an uncertainty of ± 0.1 ohm which corresponds in temperature to ± 0.25°C. The DH Laboratory determines the value of the resistance at 0°C inside the tolerance of the standard with an uncertainty of ± 0.02 ohm.

Serial number of the RTD



Installation of the temperature probe

The temperature probe is mounted in the mounting post as close as possible to the piston-cylinder. It makes possible valid and accurate temperature corrections. The probe is connected to a removable receptacle so that it can be removed and periodically recalibrated.



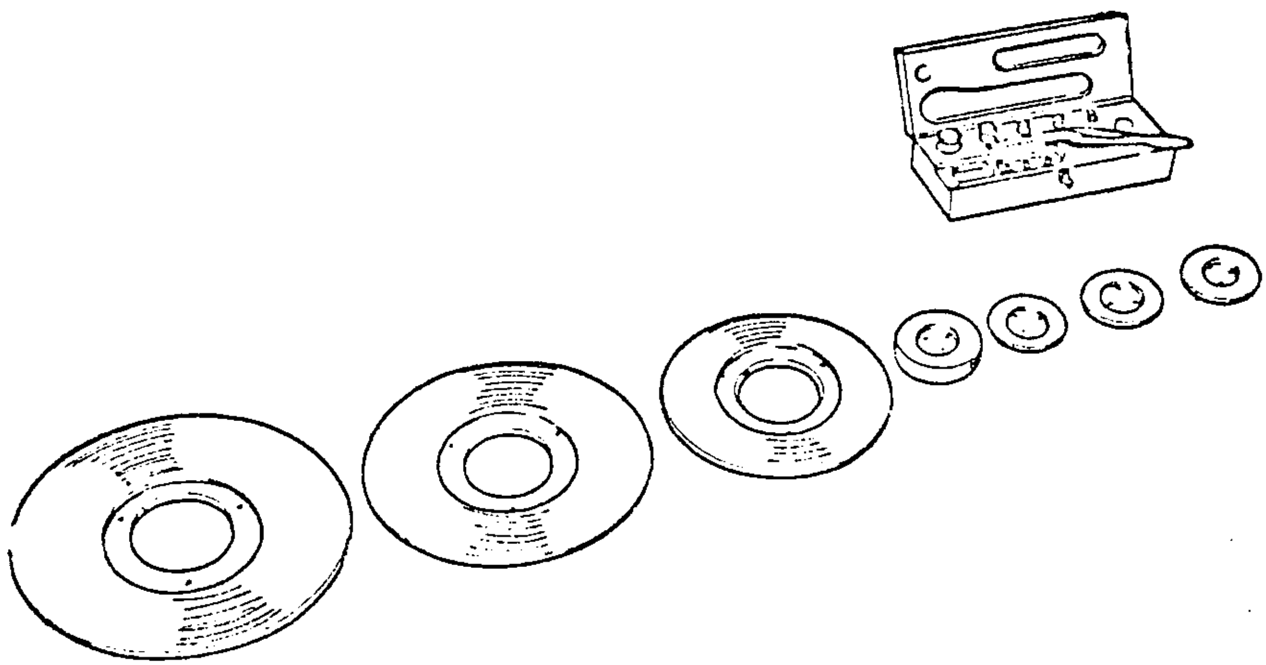
Removing the probe:

- Unscrew the gland (1) under the mounting post.
- Unscrew the 4 screws of the receptacle (2).
- Run the wire through the hole in the receptacle mount.
- Carefully remove the probe from the mounting post.

Mass set

Function : Define the value M which is subjected to acceleration due to gravity giving the force, F.

Description: Made of non-magnetic stainless steel. Masses of 1kg and above are discs with a central hole to be slipped onto the mass carrying bell.



Note: Masses are engraved in kilograms which makes it possible to interchange piston-cylinders while using the same mass set.

CHAPTER III

INSTALLATION AND START-UP

III - 1 - THE STANDARD AS DELIVERED

- The standard and its accessories are in a wooden cabinet.
- The four adjustable feet are retracted (screwed in).
- The reservoir is 3/4 full.
- The reservoir cap is tightened.
- The mounting post has installed a stainless steel piston-cylinder plug, instead of the piston-cylinder.
- The masses are in their carrying cases.
- The piston-cylinder is in its carrying case with the piston-cylinder key.

III - 2 - INSTALLING THE PISTON-CYLINDER

The overall piston-cylinder installation procedure includes the following:

1) Setting the standard on a rigid table at a convenient height.
2) Cleaning the piston-cylinder.
3) Removing the piston-cylinder plug.
4) Installing the piston-cylinder.
5) Purging air from the system.

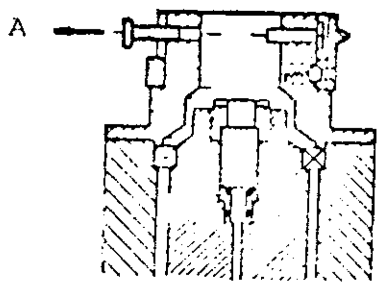
III - 2 - 1 - Cleaning the piston-cylinder

Before installing the piston-cylinder, it must be cleaned with a liquid solvent.

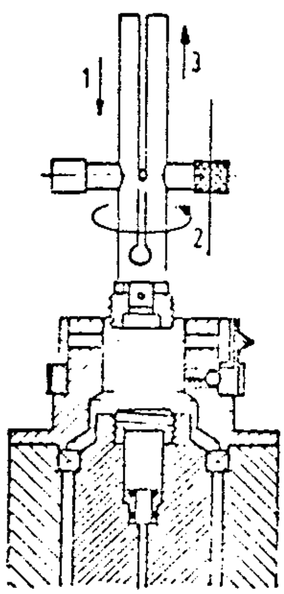
- Submerge the cylinder in the fluid and wipe the exterior and interior with a clean lint free cloth or tissue.
- Soak the piston in the fluid and wipe it off.
  NOTE: Care should be taken not to submerge the piston plate in the fluid.
- Put the piston in the cylinder. If both elements are properly cleaned, the piston moves freely without resistance in the cylinder.
- Once the elements are clean, lubricate the piston in the oil used in the standard and put the piston into the cylinder so that both pieces are lubricated.

III - 2 - 2 - Removing the piston-cylinder plug

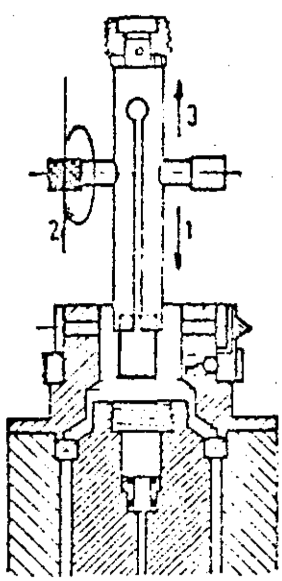
Complete the following first:
- Loosen the oil reservoir cap.
- Open the reservoir isolation valve.
- Unscrew the variable volume to mid stroke.
- Close the reservoir isolation valve.



1 - Rotate ring (A) to expose the head of the piston travel limit pins. Remove each pin as it appears.



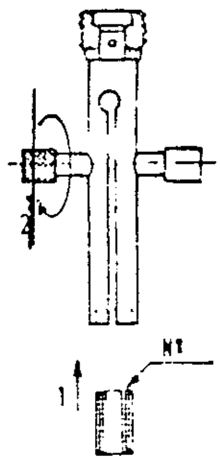
2 - Insert the pin end of the piston-cylinder key into the cylinder retaining nut. Unscrew and remove the nut. (A lock ball keeps the nut on the key).



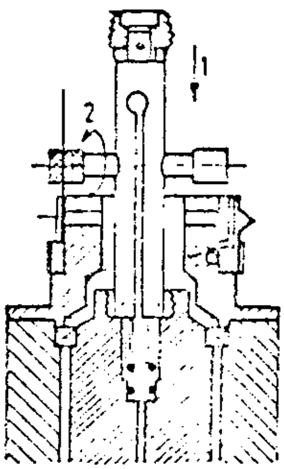
3 - Invert the key and set the notched end over the plug and tighten the T handle as indicated. Remove the key and plug.

III - 2 - 3 - Installing the piston-cylinder

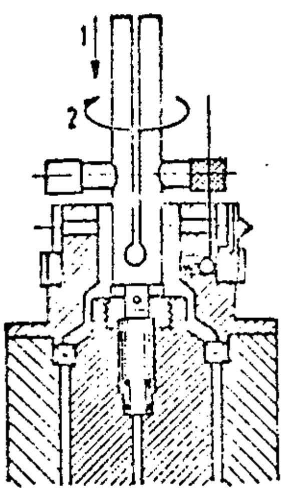
A) Installing the cylinder



1 - Put the cylinder into the notched end of the piston-cylinder key. Tighten T handle.
NOTE: The cylinder serial number and/or X notation must face upwards after installation. To do so, put this end of the cylinder into the key.



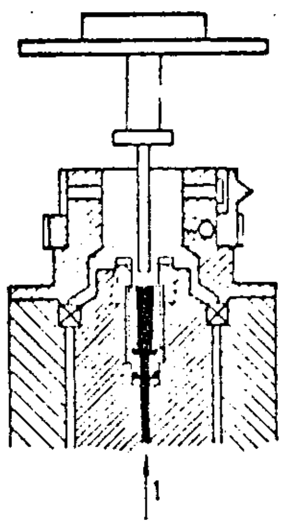
2 - Insert the cylinder in the mounting post and loosen the T handle. Remove the key.



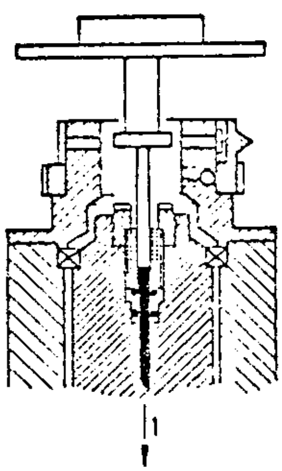
3 - Invert tool. Reinstall the piston-cylinder retaining nut. Tighten to the end of its thread.

NOTE: Hand tighten only. High torque is not required.

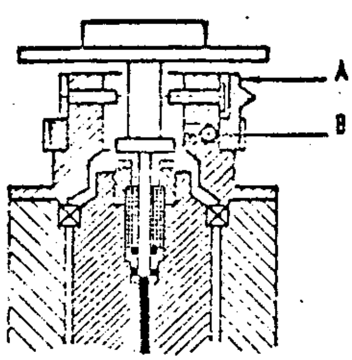
B) Installing the piston



1 - Pump oil to the top of the cylinder using the priming pump.



2 - Insert the piston into the cylinder.



3 - Replace the three piston travel limit pins and rotate ring (A) to engage locking ball (B).

III - 2 - 4 - Purging the system of air

After installing the piston-cylinder, the system should be purged of any air which may be present.

1 - Check that:
- The quick-connecting head is plugged.
- The oil reservoir cap is loosened.
- The piston travel limit pins are installed.
- The mass carrying bell is not on the piston.

2 - Close the reservoir isolation valve.

3 - Increase the pressure in the system using the priming pump until the handle becomes hard to move.

4 - Open rapidly and completely the reservoir isolation valve.

5 - Close the reservoir isolation valve and repeat operation 2, 3 and 4 two or three times.

III - 3 - START-UP

The description below pertains to start-ups with the piston-cylinder already installed.

1 - Level the standard using the 4 leveling feet and the bubble level:
- Unscrew all four feet a few turns.
- Screw in completely the front right foot.
- Push down the left rear of the standard to stabilize it on the three feet that are screwed out.
- Put the bubble into proper position on the right/left axis using the front left foot.
- Put the bubble into the reference circle using the right rear foot.
- Unscrew the front right foot to stabilize the standard.

2 - If you have a standard with a switchable voltage motor, select the appropriate voltage (110V or 220V) with the switch on the inside of the standard.

3 - Connect the power supply cable to the receptacle on the rear of the standard. Plug the cable into the power supply.

4 - Connect the temperature probe cable to the receptacle on the rear of the standard and to a digital ohmmeter (S', S and S^2 standards only) (see Chapter IV - 4).

5 - Proceed as follows:
   - Plug the quick-connecting head.
   - Open the reservoir isolation valve.
   - Put the variable volume at mid-stroke.
   - Close the reservoir isolation valve.

6 - Switch the motor on to rotate the piston.

7 - Place the mass carrying bell on the piston plate and load 10kgs on the bell.

8 - Increase the pressure using the priming pump. Pump the handle until it becomes hard (do not force the handle). Then, if necessary, screw in the variable volume until the piston reaches its fully up position.

9 - Wait approximately two minutes. The purpose of this step is to form the pressurized components and to check the system for leaks.

10 - Decrease the pressure by unscrewing the variable volume until the piston reaches its fully down position.

11 - Open the reservoir isolation valve to bring the pressure inside the standard back to ambient.

III - 4 - CALIBRATION PROCEDURE

1) Connect the system under test to the appropriate quick-connector.
2) Remove the plug from the quick-connecting head.
3) Close the reservoir isolation valve.
4) Using the variable volume, bring oil to the top of the connecting head O-ring assembly.
5) Connect the system under test to the connecting head.
6) Unscrew the variable volume leaving about one inch of travel.

7) Load the mass carrying bell with the quantity of mass corresponding to the first pressure increment.
8) Prime the standard and the system under test using the priming pump until pumping becomes hard to move. (do not force the handle)
9) Screw in the variable volume until the piston moves up to mid-float position as defined by the piston displacement indicator.
10) Take readings of the system under test.
11) Add the masses necessary to define the next pressure increment.
12) Repeat 9, 10, and 11 for subsequent ascending pressure increments.
13) For descending pressure increments, remove the appropriate masses and unscrew the variable volume.
14) After the last increment, unscrew the variable volume until the piston is in its full down position. Open the reservoir isolation valve and return to ambient pressure.

III - 5 - PRECAUTIONS TO BE TAKEN TO ASSURE GOOD MEASUREMENTS

1) Clean the piston-cylinder thoroughly before installation.
2) Install the cylinder in the correct direction: serial number and/or X upwards.
3) Verify that the piston travel limit pins are installed.
4) Check that the oil reservoir is full.
5) Loosen the oil reservoir cap.
6) Purge air from the standard and the system under test.
7) Level the standard and check the level when different mass values are loaded.
8) Rotate the piston.
9) Always put the piston in fully down position before opening any valve.
10) Calibrate instruments in their operating position.

III - 6 - SHUT-DOWN PROCEDURE

1) Open the reservoir isolation valve.
2) Screw the variable volume all the way in.
3) Close the reservoir isolation valve.
4) Tighten the oil reservoir cap.
5) Turn off the motor.
6) Cover the standard with its plastic cover.
7) Put the masses in their storage cases.

III - 7 - PERIODIC MAINTENANCE

1) Empty the oil from the oil run off cup (never reuse this oil).
2) Open the sump drain-cock and drain off oil until it runs clear.
3) Clean piston plate and masses.

III - 8 - PERIODIC OPERATIONAL CHECK

For regular use, it is recommended to return the standard to DH every three years for a system overhaul. Production and high volume applications may require more frequent maintenance.

III - 9 - RECALIBRATION OF PISTON-CYLINDER AND MASSES

Periodic recalibration of the piston-cylinder and masses assures the long term reliability and optional metrological performance of the system. Though other organizations can perform these calibrations, it is recommended that the DH Calibration, Test and Service Division be used in order to receive data which allows the exploitation of piston K_N factors and whole number masses. The DH calibration chain also documents long term repeatability of the system well inside of accuracy tolerances.

- N Class Standards
  Two years after delivery, a complete recalibration by the CTS Division is advised. If no significant change from original data has occured, adoption of a three year calibration cycle is recommended.
- S', S and S^2 Class Standards
  The first and second year after delivery, a complete recalibration by the CTS Division is advised. If no significant change from original data has occurred, adoption of a two year calibration cycle is recommended.

III - 10 - MOVING THE STANDARD

When moving the standard, complete the following:

1) Remove the piston-cylinder.
2) Store the piston and cylinder in their case.
3) Install the piston-cylinder plug into the mounting post.
4) Tighten the oil reservoir cap.
5) Plug the quick-connecting head.

III - 11 - SHIPPING THE STANDARD

When shipping the standard, the special shipping crates provided should be used.

1 - Follow moving the standard instructions 1-5 on previous page.
2 - Completely screw in the four adjustable feet.
3 - Put the standard, the piston-cylinder, and the masses in their carrying cases.
4 - Store the standard's accessories in the top of the standard's case.
5 - Pack all the cases in their shipping crates.

III - 12 - STORING THE STANDARD

Follow shipping the standard instructions 1-5 above. Storage temperature: -15°C +65°C (+5 to +150°F).

CHAPTER IV

METROLOGICAL THEORY OF THE PRESSURE STANDARD

IV - 1 - FUNDAMENTAL THEORY

IV - 1 - 1 - General

The formula which gives the pressure at the reference level of the standard is:

$$P = \frac{Mg\left(1 - \frac{\rho a}{\rho m}\right)}{A_{(\theta,P)}}$$

Where:
- P: pressure
- M: total mass on the piston
- g: acceleration due to gravity
- ρa: air density
- ρm: mass density
- $A_{(\theta,P)}$: effective area of the piston cylinder at temperature θ and pressure P.

The expression $1 - \frac{\rho a}{\rho m}$ is the correction due to the effect

of air buoyancy on the masses. Under standard gravity and air density conditions, pressure is defined as:

$$P = \frac{M gn\left(1 - \frac{\rho a}{\rho m}\right)}{A_{(\theta,P)}}$$

Where:
- gn: $9.80665 m/s^2$ (standard gravity)
- ρa: air density at 20°C and atmospheric pressure of 1013.25mbar: $1.2 kg/m^3$
- ρm: density of stainless steel: $7920 kg/m^3$.
- $A_{(\theta,P)}$: effective area of the piston-cylinder at temperature θ and pressure P.

In writing:

$$K_{N(\theta,P)} = \frac{gn\left(1 - \frac{\rho a}{\rho m}\right)}{A_{(\theta,P)}} \quad (1)$$

One obtains:

$$P = K_{N(\theta,P)} \times M \quad (2)$$

The effective areas of DH piston-cylinders is such that K_N is a whole number when θ = 20°C and P = 0 psig.

$K_{N(20,0)}$ is called the normal conversion coefficient. It is a whole number for each piston-cylinder such that under standard conditions a mass of 1kg is put into equilibrium by a pressure of $K_{N(20,0)}$ psi or $K_{N(20,0)}$ bar.

Piston-cylinders, for this model, are available with the following $K_{N(20,0)}$:

Measurements in psi

$K_{N(20,0)}$ = 100psi/kg
$K_{N(20,0)}$ = 200psi/kg
$K_{N(20,0)}$ = 300psi/kg
$K_{N(20,0)}$ = 500psi/kg

Measurements in bar

$K_{N(20,0)}$ = 5bar/kg
$K_{N(20,0)}$ = 10bar/kg
$K_{N(20,0)}$ = 20bar/kg
$K_{N(20,0)}$ = 50bar/kg

IV - 1 - 2 - Correction for acceleration due to gravity

At the location where the standard is used, the local gravity gl is usually different from standard gravity gn.

This gives:

$$P = M \times gl \frac{\left(1 - \frac{\rho_a}{\rho_m}\right)}{A_{(\theta,P)}}$$

By writing:

$$K_{L(\theta,P)} = \frac{gl \times \left(1 - \frac{\rho_a}{\rho_m}\right)}{A_{(\theta,P)}} \qquad (3)$$

From which:

$$K_L(20,0) = \frac{gl \left(1 - \frac{\rho_a}{\rho_m}\right)}{A_{(20,0)}}$$

One can write:

$$K_{L(20,0)} = \frac{gl\left(1 - \frac{\rho_a}{\rho_m}\right)}{A_{(20,0)}} = \frac{\left(gn\ 1 - \frac{\rho_a}{\rho_m}\right)}{A_{(20,0)}} \times \frac{gl}{gn} = K_{N(20,0)} \frac{gl}{gn} \qquad (3')$$

With:

$$Cg = \frac{gl}{gn}$$

Cg is the gravity correction. This value can be found in the Cg annex.

$K_{L(20,0)}$ is called the local conversion coefficient, which is defined b[y] the piston-cylinder used and the location of use.

For a given location K_L is a constant:

$$K_{L(20,0)} = K_{N(20,0)} \times Cg \qquad (4)$$

IV - 1 - 3 - Correction of effective areas as a function of temperature and pressure

When the temperature is other than 20°C and the gauge pressure other than zero, the change in effective area is defined by the following formula:

$$A_{(\theta,P)} = A_{(20,0)} [1 + (\alpha C + \alpha P)(\theta - 20)] (1 + \lambda P) \qquad (5)$$

Where:

$A_{(\theta, P)}$:	effective area at temperature θ and pressure P.
$A_{(20,0)}$:	effective area at temperature 20°C and pressure 0 psi.
αC:	thermal expansivity of the cylinder.
αP:	thermal expansivity of the piston.
θ:	temperature.
λ:	distortion coefficient of the effective area with pressure.
P:	pressure.

IV - 1 - 4 - General formula

From the formulas (3), (3') and (5) we obtain:

$$K_{L(\theta,P)} = K_{L(20,0)} [1 - (\alpha P + \alpha C)(\theta - 20)] (1 - \lambda P)$$

If $C_\theta = 1 - (\alpha P - \alpha C)(\theta - 20)$ one obtains $K_{L(\theta,P)} =$

$$K_{L(20,0)} \; C_\theta \; (1 - \lambda P) \qquad (6)$$

C_θ is the correction coefficient for temperature. This value can be found in the annex. Using formulas (6) and (4), it is possible to calculate P.

$$K_{L(20,0)} = K_{N(20,0)} \times Cg$$

$$P = K_{N(20,0)} \times Cg \times C_\theta \times (1 - \lambda P) \times M$$

IV - 2 - PRESSURE CALCULATION

The following parameters are given with the standard:

- $A(mes)_{(20,0)}$: Measured effective area at 20°C and 0 gauge pressure.
- $K_{N(20,0)}$: Normal conversion coefficient at 20°C and 0 gauge pressure.
- αP: Thermal expansivity of the piston.
- αC: Thermal expansivity of the cylinder.
- λ: Distortion coefficient of the piston-cylinder.
- Ro: Resistance value of the RTD at 0°C.

Pressure is calculated as follows:

IV - 2 - 1 - Calculation of the local conversion coefficient at 20°C and 0 gauge pressure

$$K_{L(20,0)} = K_{N(20,0)} \times Cg$$

- Cg: correction coefficient for gravity for a given location.
- $K_{L(20,0)}$ is a constant for one location.

IV - 2 - 2 - Calculation of the pressure at the reference level of the standard

$$P = K_{L(\theta,P)} \times M$$

Where: $K_{L(\theta,P)} = K_{L(20,0)} \times C_{\theta} \times (1-\lambda P)$

- M: total mass on the piston.
- P: the value of P used to calculate $K_{L(\theta,P)}$. This value can be calculated using nominal values as follows:

$$P = K_{L(20,0)} \times M$$

With: $\theta = \frac{Re-Ro}{0.389}$

IV - 2 - 3 - Calculation of the pressure at the height of the instrument under test

P instrument under test = P standard $+\Delta P$. ΔP is the fluid head correction which can be positive or negative.

IV - 2 - 4 - Simplified calculation of the pressure

For calculations where maximum accuracy is not imperative, since the value of the distortion coefficient is very small, a median conversion coefficient can be used.

$$K_{L(\theta, \frac{Pmax}{2})} = K_{L(20,0)} - C_{\theta} \left(1- \frac{\lambda Pmax}{2}\right)$$

The maximum additional uncertainty on a pressure measurement is $\pm \frac{\lambda P_{max}}{2}$

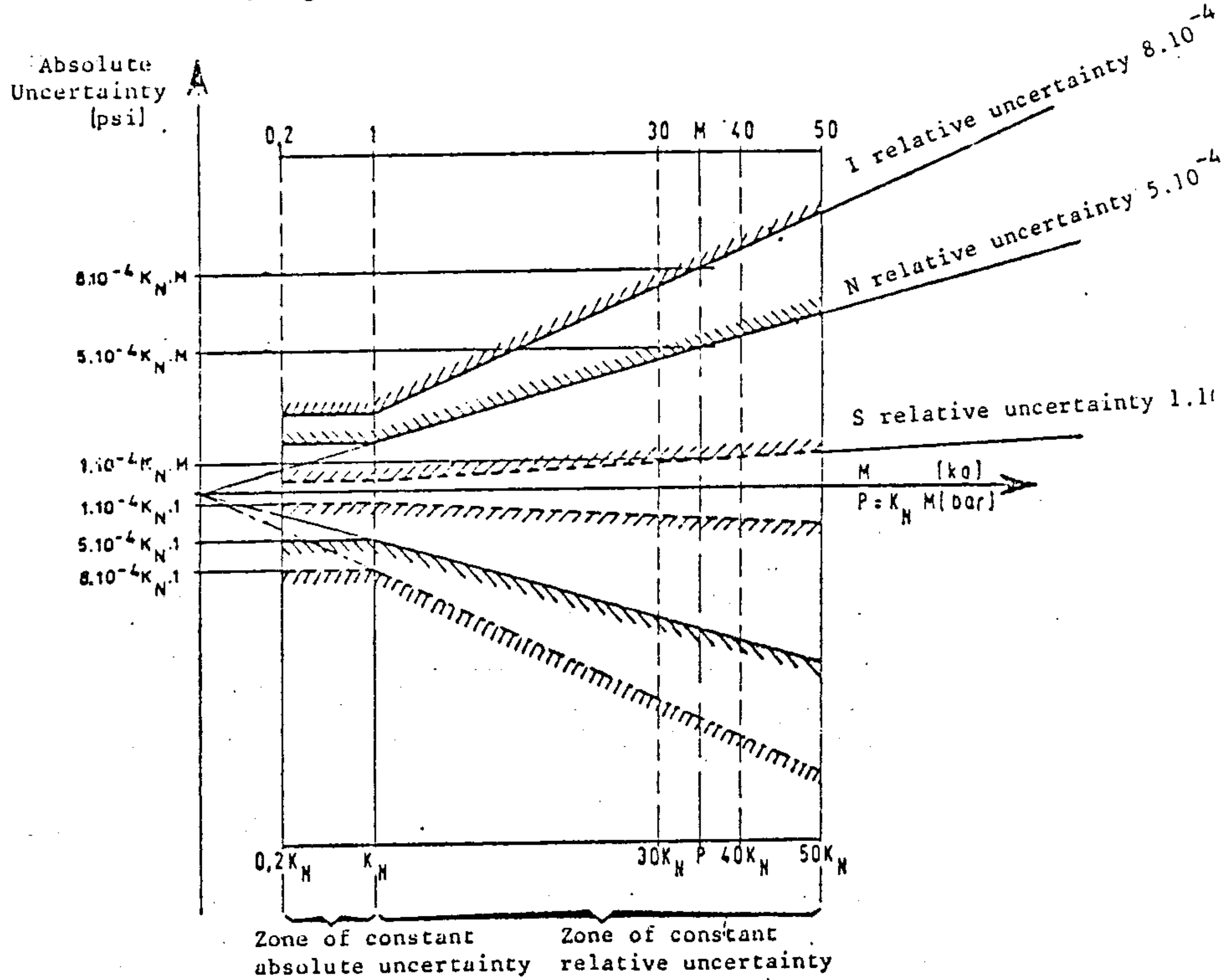
IV - 3 - ACCURACY OF THE PRESSURE STANDARDS

The accuracy class of a pressure standard defines the relative uncertainty on a measured pressure.

The lower limit is the pressure which puts into equilibrium 1kg of mass, which is a value equal to the K_N of the piston-cylinder used. 1kg is defined by the mass of the piston + the mass of the mass carrying bell.

At 1kg and above, there is enough rotation inertia to assure good mobility of the piston. In addition, the piston displacement indicator can be used.

Reference pressures between 0.2kg (the piston alone) and 1kg (piston + bell) can be defined. In this range however, there is a constant absolute error equal to the relative error on the pressure defined by 1kg.



IV - 4 - TEMPERATURE PROBE (S', S and S^2 accuracy only)

IV - 4 - 1 - Measuring principal

In the range of 0 - 40°C, the temperature is proportional to the change in resistance of the platinum RTD following the formula:

$$\theta = \frac{Re-Ro}{0.389}$$

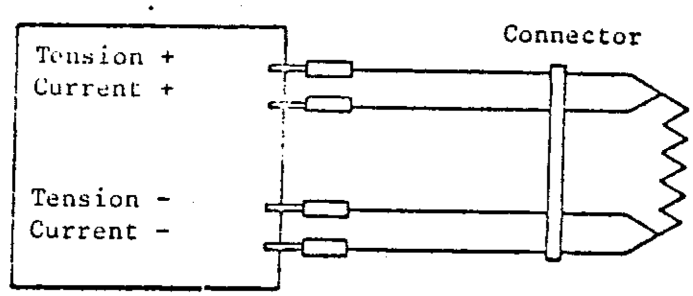
Where:
- θ: temperature in degrees C.
- Re: read resistance of the platinum RTD at temperature θ.
- Ro: resistance of the platinum RTD at 0°C (supplied by DH).
- 0.389: conversion coefficient of ohms to degrees C following DIN norm 43760.

The resistance used must be the resistance of the platinum RTD only excluding the resistance of the read-out cable. This is why a four wire cable is used.
- Two wires are used to give a constant power supply to the RTD (5mA max).
- Two wires are used to measure the resistance of the RTD.

IV - 4 - 2 - Measurements

A) Using an ohmmeter allowing 4 wire measurement. In this case, there is a direct read-out of the R value.

- Connecting the temperature probe
  1) Connect the read-out cable to the receptacle on the back of the standard.
  2) Connect the 4 plugs of the cable to a digital ohmmeter (supply current must not exceed 5mA).



  3) The ohmmeter should be calibrated to read a value of about 100 ohm with an accuracy of ± 0.01ohm.

- Example of a calculation
  Value read on the ohmmeter: 107.32 Ω.
  Ohmic resistance at 0°C: 99.98 Ω.

$$\theta = \frac{107.32 - 99.98}{0.389} = 18.87°C$$

B) Using an ohmmeter allowing only 2 wire measurements. The resistance measured is the resistance of the RTD plus the resistance of the connecting leads. To diminish the effect of the resistance of the connecting leads, leads R_1 and R_2 and leads R_3 and R_4 should be connected in parallel.

R_1 red plug
R_2 red plug -- same end of the RTD

R_3 blue plug
R_4 blue plug -- same end of the RTD

Since the length of the leads is approximately equal, we can say:

$$R_1 = R_2 = R_3 = R_4$$

When the leads are in parallel, the effect of the resistance of the leads in the measurement is:

$\frac{R_1 + R_2}{4}$ for leads R_1 and R_2

$\frac{R_3 + R_4}{4}$ for leads R_3 and R_4

given:

$$\frac{R_1 + R_2}{4} + \frac{R_3 + R_4}{4}$$

Therefore, from the value measured in 2 leads, the value:

$$\frac{R_1 + R_2 + R_3 + R_4}{4}$$

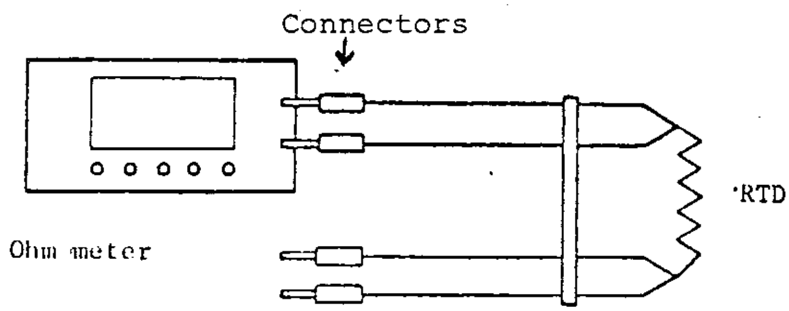
must be subtracted to obtain the value of the resistance of the RTD.

1) Determination of the $R_1 + R_2$ resistance value (red plugs)

- Put the ohmmeter in measuring mode.
- Connect the temperature probe cable to the receptacle on the standard.
- Measure the resistance between the two red leads.
- Read the value (about 0.3 Ω).

2) Determination of the $R_3 + R_4$ resistance value (blue plugs)

Proceed as for $R_1 + R_2$ on previous page using the blue plugs rather than the red plugs. Resistance should be about 0.3Ω.



3) Measuring the resistance of the RTD to determine the temperature.

- Put into parallel the two red plugs by plugging one into the other.
- Put into parallel the two blue plugs by plugging one into the other.
- Connect the red plugs and blue plugs to the ohm-meter (take care that there is no contact between the red and blue plugs).
- Read the resistance value (about 107Ω)

$$R = Re - \left(\frac{R_1 + R_2}{4} + \frac{R_3 + R_4}{4} \right)$$

4) Temperature calculation.

$$R\theta = R - \left(\frac{R_1 + R_2}{4} + \frac{R_3 + R_4}{4} \right)$$

$$\theta = \frac{R\theta - Ro}{0.389}$$

5) Example of temperature calculation.

Measure: $R_1 + R_2 = 0.3$ (following B1)
$R_3 + R_4 = 0.4$ (following B2)

$$R_\theta - \frac{(R_1 + R_2)}{4} + \frac{(R_3 + R_4)}{4} = 107.5\,\Omega \text{(following B3)}$$

from which: $R\theta = 107.5 - \left(\frac{R_1 + R_2}{4} + \frac{R_3 + R_4}{4}\right)$

$$R\theta = 107.5 - \left(\frac{0.3}{4} + \frac{0.4}{4}\right)$$

$$R\theta = 107.5 - (0.08 + 0.1)$$

$$R\theta = 107.5 - 0.18$$

$$R\theta = 107.32\ \Omega$$

For ohmic resistance of the RTD at 0°C of 99.98 (value furnished by DH given on a stamped label on the back of the standard and in the Standard's Technical Data) the temperature is:

$$\theta = \frac{R\theta - Ro}{0.389} = \frac{107.32 - 99.98}{0.389} = 18.87°C$$

Remark:

- For a given RTD cable used with a given standard, the values $R_1 + R_2$ and $R_3 + R_4$ are constants.
- Using a different cable on the same standard or vice-versa, changes the values of $R_1 + R_2$ and $R_3 + R_4$.
- The temperature value obtained using this method is accurate to ± 1°C which corresponds to ± 0.001% on the effective area of the piston.

CHAPTER V

Trouble-Shooting

V - 1 - POOR PISTON MOBILITY

- Dirty piston-cylinder
  Remove and clean the piston-cylinder (see Chapter III, 2-2)

V - 2 - PISTON DOES NOT ROTATE

1) Bad connection of the motor power supply cable.
2) Blown fuse (see Chapter II, 3).
3) Slip or deterioration of the drive belt - reinstall or replace drive belt (see Chapter VI, 3).
4) Burned out motor - replace the electrical assembly (see Chapter II, 3).

V - 3 - ABERRANT MEASUREMENTS

- Purge air from the hydraulic circuits (see Chapter III, 2-4).

V - 4 - IMPURITIES PRESENT IN THE SYSTEM

1) Purge oil through the sump (see Chapter II, 3).
2) If the system is too polluted, completely purge the standard and refill using new oil (see Chapter II, 3).

V - 5 - POOR PRESSURE STABILITY

There is a leak in the hydraulic circuit.

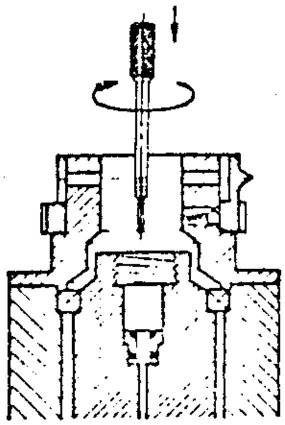
A) The leak can be located by observation.
   1) Sump drain cock: tighten the sump drain cock (see Chapter II, 3).
   2) Quick-connecting head: replace the connecting head O-ring assembly (see Chapter VI, 2).
   3) Measuring post: the oil run off cup fills rapidly. Change the measuring post O-ring assembly (see Chapter VI, 1).
   4) Loose gland nut in the hydraulic circuit: tighten the nut (No. 12 metric wrench).
      NOTE: Do not tighten nut with pressure applied.

B) The leak cannot be located by observation.
   1) Priming pump: replace the outlet check valve (see Chapter II, 3)
   2) Reservoir isolation valve: isolate the reservoir isolation valve by putting a plug on T No. 2 (see Chapter VII). Increase the pressure using the priming pump. If the leak in the system is no longer present, change the valve (see Chapter II, 3).

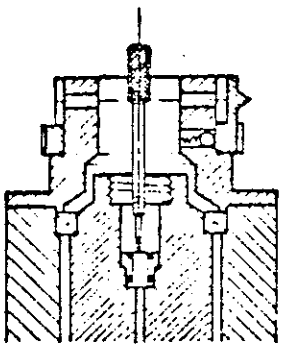
NOTE: Manufacturer's reference numbers of the sub-assemblies are given in Chapter II, 2.

CHAPTER VI - MAINTENANCE

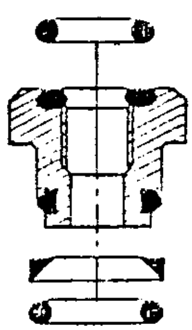
VI - 1 - CHANGING THE MOUNTING POST O-RING ASSEMBLY NO. 41096



1 - Remove the cylinder and screw the special tool into the O-ring assembly.



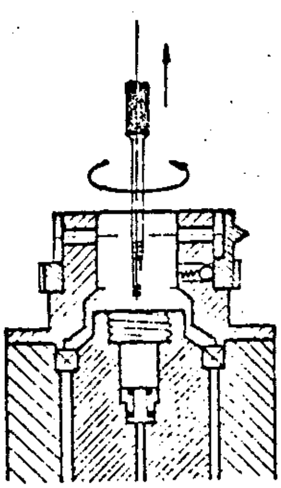
2 - Pull the tool upwards to extract the O-ring assembly.



The upper O-ring is an "R 5a".

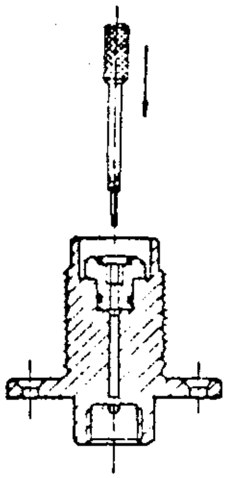
The anti-extrusion ring is ref. no. 36871.

The lower O-ring is an "R 6".

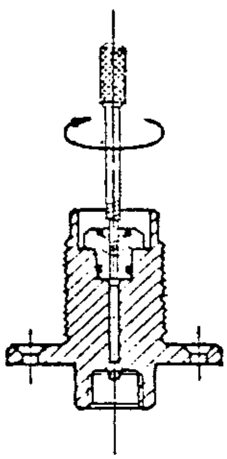


3 - Screw a new O-ring assembly onto the special tool, push it into place in the mounting post and unscrew and remove the special tool.

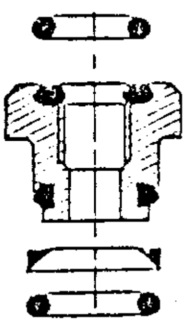
VI - 2 - CHANGING THE QUICK-CONNECTING HEAD O-RING ASSEMBLY NO. 41087



1 - Remove the knurled nut from the quick-connecting head.



2 - Screw the special tool into the O-ring assembly and pull upwards to remove the O-ring assembly.

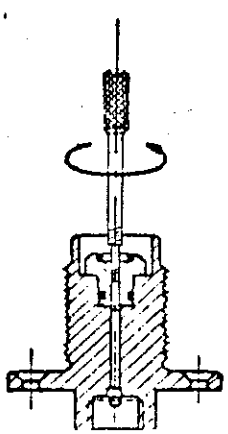


The upper O-ring is an "R 4".

The O-ring assembly is ref. no. 41087.

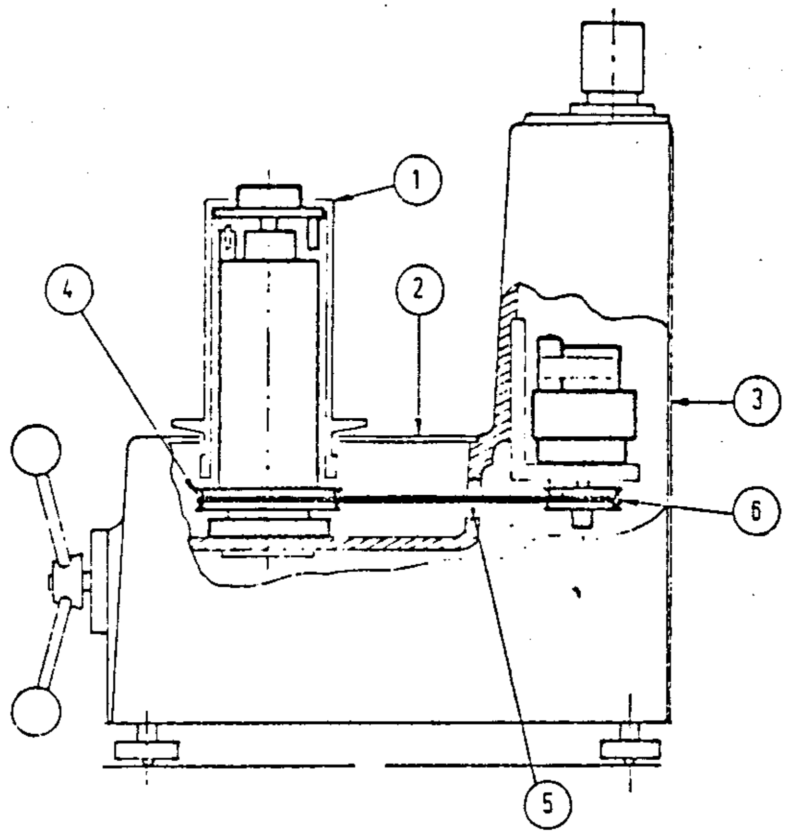
The anti-extrusion ring is ref. no. 40900.

The lower O-ring is an "R 5".



3 - Screw a new O-ring assembly onto the special tool and push it into the quick-connecting head. Unscrew the special tool.

VI - 3 - REPLACING THE DRIVE BELT



1) Remove the mass carrying bell (1), the upper cover (2) and the rear cover (3).

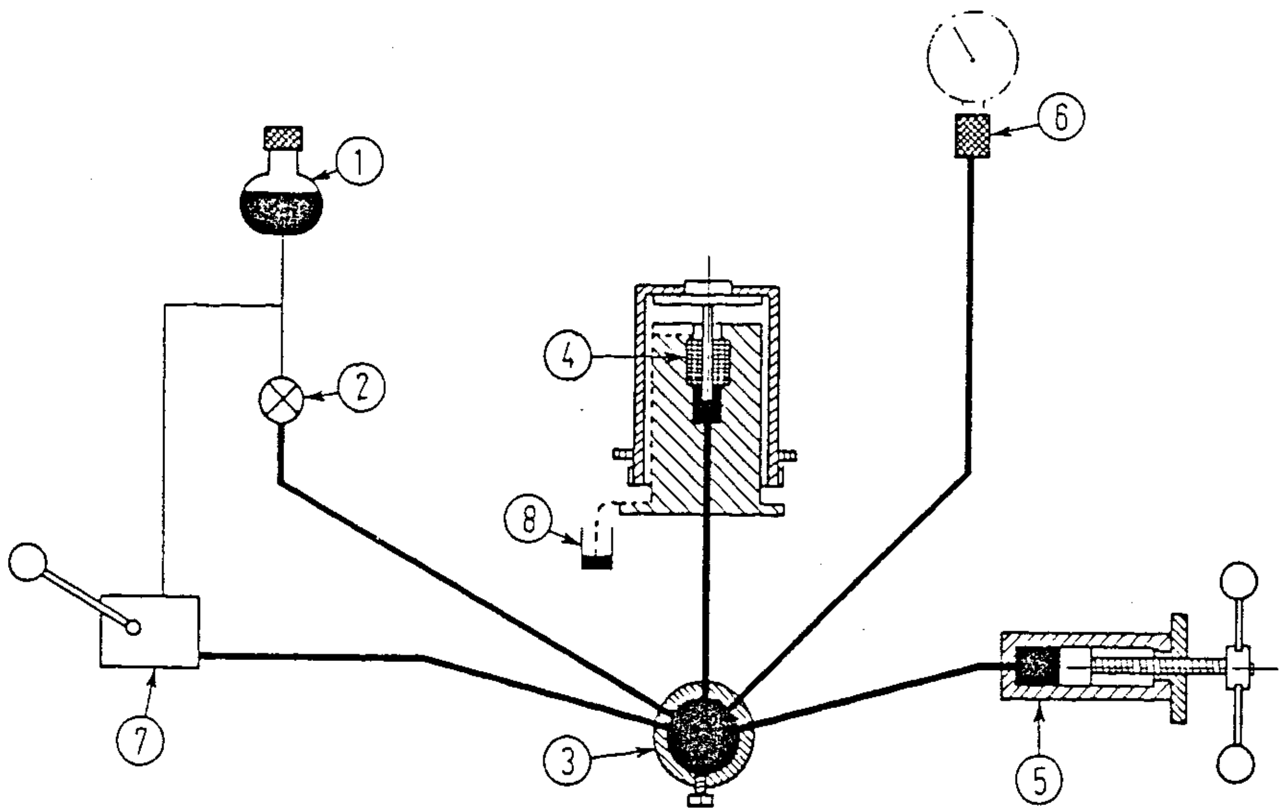
2) Remove the used belt.

3) Slip the new belt over the pulley (4) and position it in the groove. Pass the belt through the opening (5) and position it in the groove of the motor pulley (6).

4) Reinstall the protective covers, (2) and (3).

CHAPTER VII

HYDRAULIC CIRCUIT SCHEMATIC



1 - Oil Reservoir
2 - Oil reservoir isolation valve
3 - Sump
4 - Mounting post
5 - Variable volume
6 - Quick-connecting head
7 - Priming pump
8 - Waste-oil cup

ANNEXES

- Values of the Correction Factor C_g
- Temperature Correction
- Temperature Correction
- Pressure Conversion Factors
- DH 400 High Pressure Flexible Tubes
- Sebacate Date
- Krytox Material Data Sheet

VALUES OF THE CORRECTION FACTOR Cg AS A FUNCTION OF LOCAL GRAVITY

$$Cg = \frac{g_L}{g_N}$$

g_L : local gravity

g_N : standard gravity = 9.80665 m/s².

g_L [m/s²]	Cg
9.7800	0.99728
05	33
9.7810	0.99738
15	44
9.7820	0.99749
25	54
9.7830	0.99759
35	64
9.7840	0.99769
45	74
9.7850	0.99779
55	84
9.7860	0.99789
65	95
9.7870	0.99800
75	05
9.7880	0.99810
85	15
9.7890	0.99820
95	25
9.7900	0.99830
05	35
9.7910	0.99840
15	46
9.7920	0.99851
25	56

g_L [m/s²]	Cg
9.7930	0.99861
35	66
9.7940	0.99871
45	76
9.7950	0.99881
55	86
9.7960	0.99891
65	96
9.7970	0.99902
75	07
9.7980	0.99912
85	17
9.7990	0.99922
95	27
9.8000	0.99932
05	37
9.8010	0.99942
15	47
9.8020	0.99953
25	58
9.8030	0.99963
35	68
9.8040	0.99973
45	78
9.8050	0.99983
55	88

g_L [m/s²]	Cg
9.8060	0.99993
9.80665	1.00000
9.8070	1.00004
75	09
9.8080	1.00014
85	19
9.8090	1.00024
95	29
9.8100	1.00034
05	39
9.8110	1.00044
15	49
9.8120	1.00055
25	60
9.8130	1.00065
35	70
9.8140	1.00075
45	70
9.8150	1.00085
55	90
9.8160	1.00095
65	100
9.8170	1.00106
75	11
9.8180	1.00116
85	21

g_L [m/s²]	Cg
9.8190	1.00126
95	31
9.8200	1.00136
05	41
9.8210	1.00146
15	51
9.8220	1.00157
25	62
9.8230	1.00167
35	72
9.8240	1.00177
45	82
9.8250	1.00187
55	92
9.8260	1.00197
65	202
9.8270	1.00208
75	13
9.8280	1.00218
85	23
9.8290	1.00228
95	33
9.8300	1.00238
05	43
9.8310	1.00248
15	53

TEMPERATURE CORRECTION

Piston and cylinder in tungsten carbide

value of $C_\theta = 1 - (\alpha_p + \alpha_c)(\theta - 20)$ $\alpha_p + \alpha_c = 9 \times 10^{-6}$ °C^{-1}

(°C)	C_θ
5	1,00014
6	1,00013
7	1.00012
8	1.00011
9	1.00010
10	1.00009
11	1.00008
12	1.00007
13	1.00006
14	1.00005
15	1.00004
16	1.00004
17	1.00003
18	1.00002
19	1.00001

(°C)	C_θ
20	1,00000
21	0.99999
22	0.99998
23	0.99997
24	0.99996
25	0.99996
26	0.99995
27	0.99994
28	0.99993
29	0.99992
30	0.99991
31	0.99990
32	0.99989
33	0.99988
34	0.99987

(°C)	C_θ
35	0.99986
36	0.99986
37	0.99985
38	0.99984
39	0.99983
40	0.99982
41	0.99981
42	0.99980
43	0.99979
44	0.99978
45	0.99978
46	0.99977
47	0.99976
48	0.99975
49	0.99974

TEMPERATURE CORRECTION

Piston in steel and cylinder in tungsten carbide

$$c_\theta = 1-(\alpha_p+\alpha_c)(\theta-20)$$

α_p : Thermal expansivity of steel $=1.05 \times 10^{-5}$ [°C^{-1}]
α_c : Thermal expansivity of tungsten carbide $= 4.50 \times 10^{-6}$ [°C^{-1}]
θ : Temperature of the piston cylinder [°C]

[°C]	c_θ
5	1.00023
6	1.00021
7	1.00020
8	1.00018
9	1.00017
10	1.00015
11	1.00014
12	1.00012
13	1.00011
14	1.00009
15	1.00008
16	1.00006
17	1.00005
18	1.00003
19	1.00002

[°C]	c_θ
20	1.00000
21	0.99999
22	0.99997
23	0.99996
24	0.99994
25	0.99993
26	0.99991
27	0.99990
28	0.99988
29	0.99987
30	0.99985
31	0.99984
32	0.99982
33	0.99981
34	0.99979

[°C]	c_θ
35	0.99978
36	0.99976
37	0.99975
38	0.99973
39	0.99972
40	0.99970
41	0.99969
42	0.99967
43	0.99966
44	0.99964
45	0.99963
46	0.99961
47	0.99960
48	0.99958
49	0.99957

PRESSURE CONVERSION FACTORS

DHI PRESSURE STANDARDS

	Pa (N/m^2)	bar	psi [1]	kg/cm^2 [1]	mmHg (torr) [1 2]	inHg [1 2]	m H_2O [1 3]	in H_2O [1 3]
1 Pa (N/m^2) =	1	1.000 000 x 10^{-5}	1.450 377 x 10^{-4}	1.019 716 x 10^{-5}	7.500 627 x 10^{-3}	2.953 003 x 10^{-4}	1.019 716 x 10^{-4}	4.014 631 x 10^{-3}
1 bar =	1.000 000 x 10^{5}	1	1.450 377 x 10	1.019716 -	7.500.627 x 10^{2}	2.953 003 x 10	1.019 716 x 10	4.014 631 x 10^{2}
[1] 1 psi =	6.894 757 x 10^{3}	6.894 757 x 10^{-2}	1	7.030 696 x 10^{-2}	5.171 500 x 10	2.036 024 -	7.030 696 x 10^{-1}	2.767 990 x 10
[1] 1 kg/cm^2 =	9.306 650 x 10^{4}	9.306 650 x 10^{-1}	1.422 334 x 10	1	7.355 602 x 10^{2}	2.395 906 x 10	1.000 00 x 10	3.937 008 x 10^{2}
[1 2] 1 mm Hg (torr) =	1.333 222 x 10^{2}	1.333 222 x 10^{-3}	1.933 675 x 10^{-2}	1.359 508 x 10^{-3}	1	3.937 008 x 10^{-2}	1.359 508 x 10^{-2}	5.352 394 x 10^{-1}
[1 2] 1 in Hg =	3.386 384 x 10^{3}	3.386 384 x 10^{-2}	4.911 534 x 10^{-1}	3.453 150 x 10^{-2}	2.540 000 x 10	1	3.453 150 x 10^{-1}	1.359 508 x 10
[1 3] 1 m H_2O =	9.306 650 x 10^{3}	9.306 650 x 10^{-2}	1.422 334 -	1.000 000 x 10^{-1}	7.355 602 x 10	2.395 906 -	1	3.937 008 x 10
[1 3] 1 in H_2O =	2.490 389 x 10^{2}	2.490 399 x 10^{-3}	3.612 729 x 10^{-2}	2.540 000 x 10^{-3}	1.868 323 -	7.355 602 x 10^{-2}	2.540 000 x 10^{-2}	1

1. - Normal gravity: $gn=9.80665\ m/s^2$

2. - Density of mercury at 0 C and standard Atmospheric pressure (101325Pa) $Hg=1.359508 \times 10^4\ kg/m^3$

3. - Density of water at 4 C and standard Atmospheric pressure (101325Pa) $H\ O=1.00000 \times 10^3\ kg/m^3$

plasticizer performance data

ROHM AND HAAS COMPANY

MONOPLEX® DOS

Monoplex DOS (di-2-ethylhexyl sebacate) is an ester-type plasticizer which has been used for many years as a standard in vinyl compounds requiring low temperature flexibility.

The most important features of Monoplex DOS are low volatility, high plasticizing efficiency, excellent resistance to extraction by water, soaps, and detergents, and excellent flexibility at low temperatures. Like other plasticizers which impart low-temperature flexibility, Monoplex DOS is susceptible to hydrocarbon extraction and deficient in migration resistance.

In plastisols, Monoplex DOS exhibits very low viscosity (about one-third the viscosity of plastisols based on DOP) and excellent viscosity stability. Monoplex DOS is often used in combination with other plasticizers to improve the viscosity characteristics of vinyl plastisols and to improve low temperature properties.

Suggested uses include:

- Film and sheeting for use at low temperatures
- Low viscosity plastisols
- Primary electrical insulation
- Electrical jacketing
- Strip-coating compounds

Property	Monoplex DOS					Dioctyl Phthalate
% Plasticizer	20	35	40	50	35*	35*
Shore "A" Hardness	>100	77	69	50	77	77
Low Temp. Flexibility Brittle Point, °C $T_{135,000}$, °C	 −33 +0.5	 −54 −56	 −58 −64	 <−75 <−75	 −54 −56	 −25 −25
Tensile Strength, psi	3800	2350	2050	1300	2350	2800
Ultimate Elongation, %	230	350	375	380	350	350
Modulus at 100% Elongation, psi	3200	1200	900	370	1200	1400
Percent loss by: Volatilization Extraction by Oil Extraction by Hexane Extraction by Soapy Water	 2.2 5.3 8.2 1.0	 4.1 15.9 28.0 1.0	 5.1 18.9 36.1 1.0	 8.6 25.6 48.8 1.6	 4.1 15.9 28.0 1.0	 7.6 7.7 21.8 7.8
Compatibility Initial‡ High Humidity‡ Window Exposure‡	 G E E	 G E E	 F E E	 F− E E	 G E E	 E E E
Migration Polystyrene‡ (Resistance to mar) Foam Rubber, %	 P 10.1	 P 16.0	 P 21.9	 P 30.3	 P 16.0	 P 9.2

*At Shore "A" Hardness = 77, to facilitate comparison ‡Key: E = Excellent; G = Good; F = Fair; P = Poor

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME: THE C. P. HALL COMPANY	EMERGENCY TELEPHONE NO.: 312-767-4605
ADDRESS (Number, Street, City, State, and ZIP Code): 7300 S. Central Avenue Chicago, IL 60638	
CHEMICAL NAME AND SYNONYMS: Di-2-ethyl hexyl sebacate	TRADE NAME AND SYNONYMS: MONOPLEX® DOS
CHEMICAL FAMILY: Ester	FORMULA: $C_8H_{17}OOC(CH_2)_8COOC_8H_{17}$

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)

SECTION III - PHYSICAL DATA

BOILING POINT (°F.) @ 4 mm	450-480	SPECIFIC GRAVITY (H_2O=1)	0.911
VAPOR PRESSURE (mm Hg.)	<0.1	PERCENT, VOLATILE BY VOLUME (%)	0
VAPOR DENSITY (AIR=1)	14.5	EVAPORATION RATE (But. Ace.=1)	V. low
SOLUBILITY IN WATER	Negligible		
APPEARANCE AND ODOR	Clear straw colored liquid; mild inoffensive odor		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used): COC 432°F	FLAMMABLE LIMITS	Lel	Uel
EXTINGUISHING MEDIA: CO_2, Sand, Foam, Dry Chemical			

SPECIAL FIRE FIGHTING PROCEDURES

None

UNUSUAL FIRE AND EXPLOSION HAZARDS

None

(Continued on reverse side)

ROHM AND HAAS COMPANY
INDEPENDENCE MALL WEST
PHILADELPHIA, PENNSYLVANIA 19105

EMERGENCY PHONE: 215 592-3000 (R & H.)
800 424-9300 (CHEMTREC)

PRODUCT CODE NO.: 6-7511

MATERIAL SAFETY DATA SHEET

SECTION I – IDENTIFICATION OF PRODUCT:

TRADE NAME: Monoplex DOS

FREIGHT CLASSIFICATION: non-hazardous

FORMULA: $(CH_2)_8(CO_2C_8H_{17})_2$

CHEMICAL NAME & SYNONYMS: Di-2 ethyl hexyl sebacate

SECTION II – HAZARDOUS COMPONENTS OF MIXTURES:

COMPONENT	WEIGHT %	T.L.V.
Under current OSHA criteria, this material is considered to be non-hazardous.		

SECTION III – PHYSICAL DATA:

APPEARANCE – ODOR: Clear straw colored liquid. Mild inoffensive odor.

BOILING POINT (°F): greater than 700

VAPOR PRESSURE 68 °F (MM MERCURY): less than 0.01 mm

VAPOR DENSITY (AIR = 1): 14.5

EVAPORATION RATE (butyl acetate=1): much lower

MELTING OR FREEZING POINT (°F): no data

SPECIFIC GRAVITY (WATER = 1): 0.913

Percent Volatile (by weight): 0

SOLUBILITY IN WATER: negligible

SECTION IV – FIRE & EXPLOSION HAZARD DATA:

FLASH POINT °F (METHOD USED): 430 CCC

LOWER EXPLOSION LIMIT: N.A.[1]

UPPER EXPLOSION LIMIT: N.A.

AUTO IGNITION TEMPERATURE (°F): no data

DUST —

MINIMUM EXPLOSION CONCENTRATIONS (OZ/CU FT.): N.A.

ENERGY TO IGNITE (MILLIJOULES): N.A.

EXTINGUISHING MEDIA:

[X] FOAM [ ] ALCOHOL FOAM [X] CO_2 [X] DRY CHEMICAL [ ] WATER FOG [ ] OTHER

SPECIAL FIRE FIGHTING PROCEDURES:

UNUSUAL FIRE & EXPLOSION HAZARDS: None

SECTION V – HEALTH HAZARD DATA:

THRESHOLD LIMIT VALUE:

EFFECTS OF OVEREXPOSURE:

No ill effects are expected under normal operating conditions.
Liquid contact with eyes may cause irritation.

EMERGENCY AND FIRST AID PROCEDURES

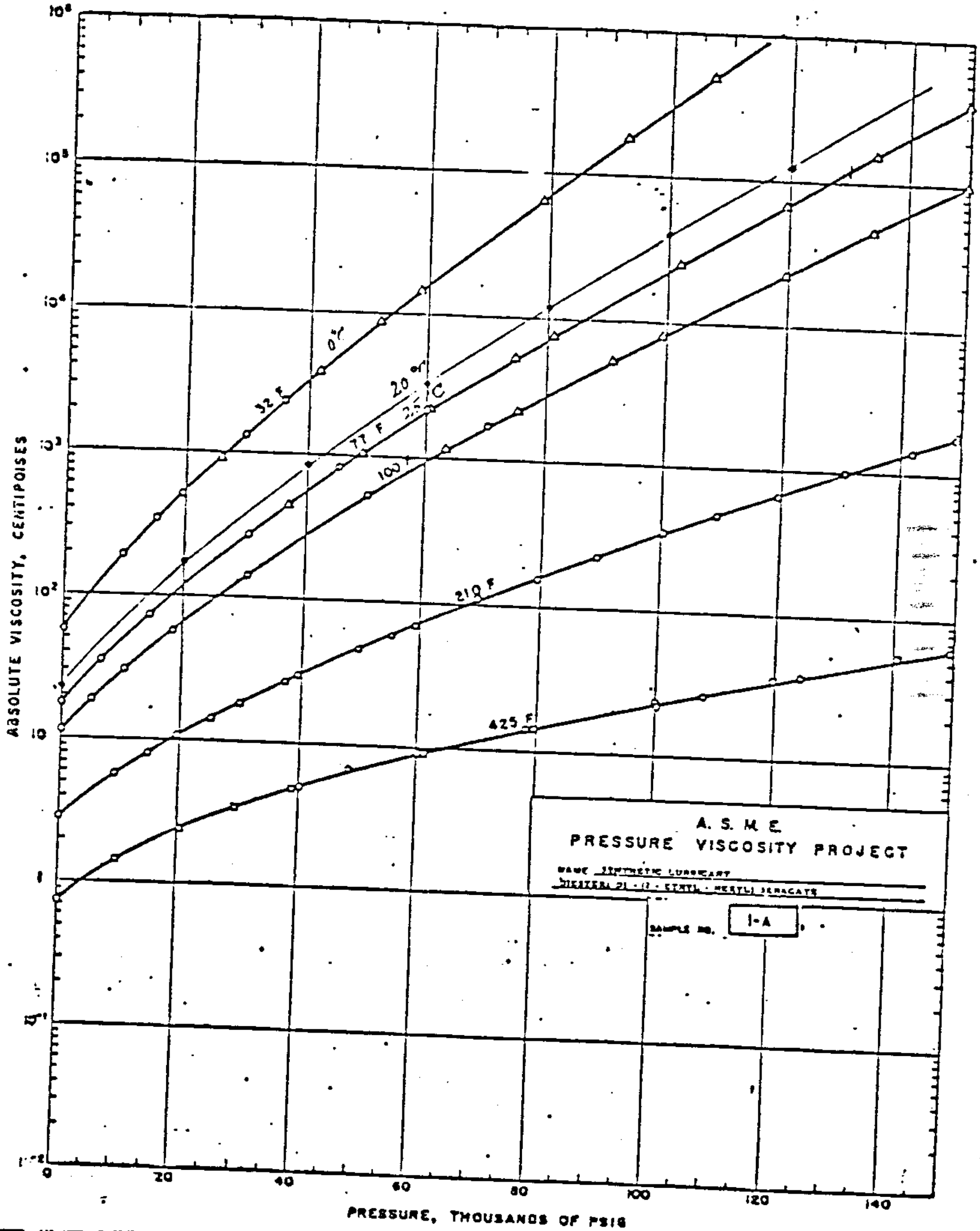
Inhalation: No hazard.

Skin & Eye Contact: Wash skin with soap and water. Flush eyes with copious amounts of water for 15 minutes.

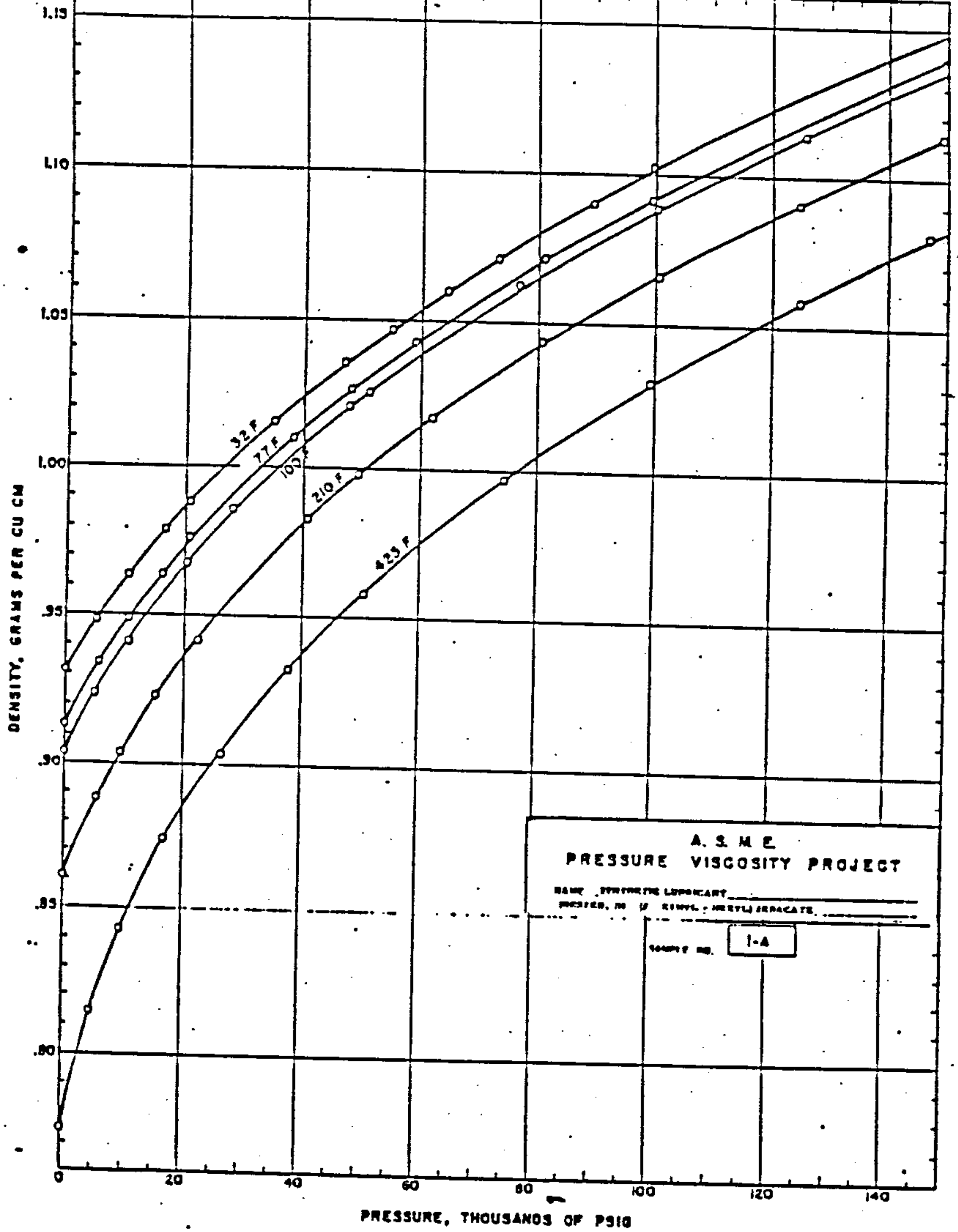
Ingestion: Induce vomiting and consult a physician.

[1]N.A.-Not Applicable

FORM 930 (FRONT) REV. 7/72



A. S. M. E.
PRESSURE VISCOSITY PROJECT
SAMPLE NO. 1-A
ABSOLUTE VISCOSITY, CENTIPOISES
PRESSURE, THOUSANDS OF PSIG
0
20
40
60
80
100
120
140
32 F
0°C
20°C
77 F
25°C
100
210 F
425 F


A. S. M. E.
PRESSURE VISCOSITY PROJECT
1-A
32 F
77 F
100 F
210 F
425 F
DENSITY, GRAMS PER CU CM
PRESSURE, THOUSANDS OF PSIG
.80
.85
.90
.95
1.00
1.05
1.10
1.15
0
20
40
60
80
100
120
140

Viscosity of di-ethyl-hexyl-sebacate as a function of pressure at 20 °C and at 25 °C

P / kbar	0,001	0,2	0,5	1,0	1,5	2	2,5	3	4	5	6	7	8
(20°C) / Poise	0,23	0,32	0,51	1,02	1,92	3,65	6,25	10,7	29,1	74,5	191	425	945
(25°C) / Poise	0,19	0,26	0,41	0,80	1,45	2,71	4,51	7,6	19,5	47,5	116	245	519

DU PONT

Performance Products

MATERIAL SAFETY DATA SHEET

MATERIAL IDENTIFICATION

NUMBER : 5635PP
NAME : "KRYTOX"* 143 SERIES & GPL FLUORINATED OILS

GRADE : AA,AB,AC,AD,AX,AY,AZ & CZ

CHEMICAL FAMILY : PERFLUOROALKYLPOLYETHERS

MANUFACTURER/DISTRIBUTOR : E.I. du Pont de Nemours & Co., Inc.
1007 Market Street
Wilmington, DE 19898

PRODUCT INFORMATION PHONE : 1-(800)441-7515
TRANSPORTATION EMERGENCY PHONE : 1-(800)424-9300
MEDICAL EMERGENCY PHONE : 1-(800)441-3637

****

HAZARDOUS COMPONENTS

Material	%
FLUORINE END-CAPPED HOMOPOLYMERS OF HEXAFLUOROPROPYLENE EPOXIDE	100

****

PHYSICAL DATA

Odor : Odorless
Form : Liquid, Viscous oil
Color : Colorless
Pour Point: -57 to -37.7 C., pH Information: Neutral,
Solubility in H2O: Negligible, Spec. Grav.: 1.86-1.91 @ 24C.

****

HAZARDOUS REACTIVITY

Instability : Stable.
Incompatibility : None reasonably foreseeable.
Decomposition : Decomposition: See Health Hazard Information. See Additional Information and References.
Polymerization : Polymerization will not occur.

E 82622

(PROTECTION INFORMATION - CONTINUED)

Protective Gloves : Impermeable

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DISPOSAL INFORMATION

Spill, Leak, or Release

NOTE: Review FIRE AND EXPLOSION HAZARDS and SAFETY PRECAUTIONS before proceeding with clean up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up.
Soak up with sawdust, sand, oil dry or other absorbent material. Remove source of heat and flame. At 260-290 deg. C. forms potentially toxic fluorine compounds. Avoid breathing decomposition products. Place in container for disposal.

Waste Disposal

Treatment, storage, transportation and disposal must be in accordance with Federal, State, and Local regulations. Recover nonusable free liquid and dispose of in an approved and permitted incinerator. Do not flush to surface water or sanitary sewer system.

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SHIPPING INFORMATION

DOT

Proper Shipping Name : Not regulated.

Shipping Containers
SEE ADD'L INFO AND REFERENCES

****

STORAGE CONDITIONS

Keep container tightly closed. Do not store or consume food, drink or tobacco in area where they may become contaminated with this material.

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ADDITIONAL INFORMATION AND REFERENCES

DECOMPOSITION
May depolymerize in the presence of some metal oxides at above 288 deg C (550 deg F). Decomposition occurs at increasing rates at temperature is raised above 355 deg C (670 deg F).

SHIPPING CONTAINERS
1 lb. polyethylene or glass bottles
4, 8, 16 lb. polyethylene bottles
5 gal. polyethylene drum

* Reg U.S. Pat. and Tm Off., Du Pont Company.
KRYTOX Fluorinated Oils are made only by Du Pont.

E 82622

(ADDITIONAL INFORMATION AND REFERENCES - CONTINUED)

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Date of latest Revision : 86/06/11

Person Responsible for MSDS : J. J. GRAHAM
CHEMICALS AND PIGMENTS
DEEPWATER, NJ 08023
800-441-9442

E 82622