FTI FLOW TECHNOLOGY™

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# TURBO-PROBE$^{R}$

## Installation, Operation
## and
## Maintenance Manual

**SERIAL NUMBER**________________________________

TURBO-PROBE$^{R}$
Installation, Operation
and
Maintenance Manual

## TM-86613  REV. J

PUBLISHED BY FTI FLOW TECHNOLOGY – March 2008

**Thank you for selecting an FTI FLOW TECHNOLOGY product for your flow measurement application.**

**Virtually every major commercial, government, and scientific organization is making use of our products, expertise and extensive technical support. This is a culmination of years of refinement in our flowmeter and calibrator designs that has resulted in the technological leadership in the flow measurements field that we enjoy.**

**We are proud of our quality products, our courteous service and welcome you, as a valued customer, to our growing family.**

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**Limitation of Liability.** Seller's obligation under the warranty shall be limited to replacing or repairing at Seller's option, the defective goods within twelve (12) months from the date of shipment, or eighteen (18) months from the date of shipment for destination outside of the United States, provided that Buyer gives Seller proper notice of any defect or failure and satisfactory proof thereof. Defective goods must be returned to Seller's plant or to a designated Seller's service center for inspection. Buyer will prepay all freight charges to return any products to Seller's plant, or other facility designated by Seller. Seller will deliver replacements for defective goods to Buyer freight prepaid. The warranty on said replacements shall be limited to the unexpired portion of the original warranty. Goods returned to Seller for which Seller provides replacement under the above warranty shall become the property of the Seller.

The limited warranty does not apply to failures caused by mishandling or misapplication. Seller's warranty obligations shall not apply to any goods that (a) are normally consumed in operation or (b) have a normal life inherently shorter than the warranty period stated herein.

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# TM-86613
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## TURBO-PROBE$^R$ TABLE OF CONTENTS CONTINUED

## 1.0 SCOPE

This manual provides information and guidance for the installation, operation, and maintenance of the Turbo-Probe$^R$ manufactured by FTI FLOW TECHNOLOGY, Tempe, Arizona.

## 2.0 PURPOSE

The contents of this manual are for general information and to describe the installation, operation, maintenance and special packaging instructions for the Turbo-Probe$^R$ series of flowmeters. This manual does not contain instructions for special applications, nor does it include instructions for accomplishing repairs of the type performed at the factory.

## 3.0 TURBO-PROBE$^R$ DESCRIPTION

The FTI FLOW TECHNOLOGY Turbo-Probe$^R$, is a volumetric flow measuring instrument. The flow sensitive element is a freely suspended, blade rotor positioned axially in the flow stream with the flowing fluid pushing against the blades.

The rotation speed of the turbine is proportional to the velocity of the fluid. If the flow passage is known, the turbine's rotational speed is also a true representation of the volume of fluid flowing through the flowmeter. The rotation of the turbine rotor generates electrical pulses in the pickoff that is attached to the probe housing in close proximity to the turning rotor. Each one of these pulses represents a discrete volume of fluid. The frequency or pulse repetition rate represents the flow rate and the accumulated pulse total represents the total volume measured.

Various configurations of the Turbo-Probe$^R$ are included in this manual. To facilitate user selection of the most suitable configuration, the probes are separated into two main components; the actuator and the flow measuring capsule element. The actuator provides the means for mounting the probe in the user's process line. The retractable Turbo-Probe permits insertion to the proper depth within the flow conduit. The capsule is the flow sensor that provides a frequency output proportional to the velocity of the flowing liquid.

Various versions of both the actuators and the capsules are included in this manual. Any capsule element can be combined with any actuator in order to meet a wide variety of flow measurement conditions.

## 3.1 TURBO-PROBE$^R$ ACTUATORS

FTI FLOW TECHNOLOGY offers two main types of Turbo-Probes, the retractable and the fixed or handheld.

### 3.1.1 Retractable Turbo-Probe$^R$

The Retractable Turbo-Probe$^R$ is an insertion type flowmeter that consists of an axial turbine flowmeter element mounted on the end of a strut. Retractable Turbo-Probes allow the user to insert them to a selected or desired depth. If installed in conjunction with a valve, they permit removal of the probe without requiring that flow be shut down though the line. They also offer the advantage of the capability to traverse the entire diameter of the process line and characterize the velocity profile, resulting in more accurate flow measurement (see Theory of Operation). Refer to Figures 1 through 13 for Turbo-Probe$^R$ Configurations.

#### 3.1.1.1 T8 and T9 Model

These are the most sophisticated insertion Turbo-Probes in FTI FLOW TECHNOLOGY's product line (See Figures 1 and 2). The T8 is offered with the standard 1" strut and the T9 with a 1.5" strut for applications where longer insertion depths and measurement of high velocity and dense fluids is required. Both types are available with various maximum insertion lengths. The minimum insertion lengths are determined by the user's installation configuration.

The probe insertion mechanism is fully enclosed and protected from the elements. The probe is inserted by turning a handwheel in the clockwise direction (counterclockwise to remove from line). A C-type fluorocarbon seal is used to prevent the process fluid from leaking even under high process pressure.

A grease fitting is built into the body of the probe to allow the used to insert grease (boat trailer type) in order to protect the insertion mechanism from moisture condensation.

#### 3.1.1.2 TL Model (Low Profile)

This probe uses a scissors type insertion mechanism, designed to allow it to be mounted in applications where space (height) is at a premium (See Figure 3). The TL Turbo-Probe is available with a maximum 8.5" (216 MM) insertion length. The minimum insertion length is determined by the user's installation configuration.

The probe is inserted by turning a handwheel in the clockwise direction (counterclockwise to remove from line). A C-type fluorocarbon seal is used to prevent the process fluid from leaking even under high process pressure.

#### 3.1.1.3 TB Model

The insertion depth of this probe can be adjusted by manually inserting the probe strut to the desired location and the tightening the Swagelok$^R$ fitting at the neck of the seal housing (See Figures 4 and 5).

A C-type fluorocarbon seal is used in this design that is the primary means of preventing leakage of the process fluid. A secondary seal is obtained by tightening the Swagelok$^R$ fitting which is equipped with a fluorocarbon ferrule. The Swagelok$^R$ fitting along with the safety cable are the means of preventing the probe from moving outward under pressure. It is important that they are tightened securely, but not so tight as to mar the finish of the probe strut.

**CAUTION**

**The safety block and cable are provided in order to protect personnel from accidental ejection of the probe strut under pressure. They must always be tightened securely.**

#### 3.1.1.4 TS Model

The insertion depth of this probe can be adjusted manually inserting the probe strut to the desired location and the tightening the Swagelok$^{R}$ fitting at the neck of the seal housing (See Figures 6, 7, 8 and 9).

No C-type fluorocarbon seal is used in this design that is mainly intended for low pressures (50 psi or 3.5 Bar maximum). The only means of sealing against leakage of the process fluid is by tightening the Swagelok$^{R}$ fitting which is equipped with a fluorocarbon ferrule which will not mar the finish of the probe strut.

### 3.1.2 Fixed and Handheld Turbo-Probe$^{R}$ (TP Model)

Fixed Turbo-probes offer a low cost alternative to flow measurement but do not allow adjustment of insertion depth or removal from the line without shutting down the process.

#### 3.1.2.1 TPA-XX-A and TPA-XX-B Models (Fixed Probes)

The insertion depth of this probe is fixed, since the strut is welded to a 150# ANSI flange that is used to mount the device on the user's process line (See Figures 10 and 11).

#### 3.1.2.2 TPA-XX-C and TPA-XX-D Models (Hand-Held Probes)

This probe does not contain any means of installation on a process line. It is meant to be used manually or installed with user provided hardware (See Figures 12 and 13).

## 3.2 CAPSULE (FLOW MEASUREMENT SENSOR)

The capsules are mainly distinguished by the type of bearing used in the turbine flow element (See Figure 14). FTI FLOW TECHNOLOGY offers three types of bearings, intended to cover a wide variety of applications (See Table 4, Bearing Application Guide).

### 3.2.1 CA-EA & CA-HA Models (Ball Bearing)

Ball bearing models for liquid or gas applications. They are the most reliable type of bearing but are subject to the temperature and corrosion limitations of their material of construction (440C stainless steel).

### 3.2.2 CA-HD Model (Carbide Journal Bearing)

Tungsten carbide journal bearings are used in liquid applications. The tungsten carbide has good wear resistance and can be used at very high temperatures (up to 1200°F or 650°C).

### 3.2.3 CA-HC Model (Jewel Pivot Bearing)

The jewel pivot bearings are mainly used in gas applications. They are subject to very little friction drag and offer the best low flow performance.

### 3.2.4 CA-HG Model (Ceramic Journal Bearing)

Ceramic Journal Bearings are used in liquid applications. Good wear resistance and high temperature capability along with an excellent corrosion resistance to most fluids. This bearing type is recommended in all types of water (0 - 18 mohm).

| MODEL NO. | FLANGE | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| T8A-24 | 3"-150# | 3/4 | 4 | 6 | 45° | 7 1/2 | 2 FT | 36.73 | 16.72 |
| | 3"-300# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 2 FT | 37.23 | 16.97 |
| | 3"-600# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 2 FT | 37.35 | 17.03 |
| T8A-36 | 3"-150# | 3/4 | 4 | 6 | 45° | 7 1/2 | 3 FT | 48.73 | 22.72 |
| | 3"-300# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 3 FT | 49.23 | 22.97 |
| | 3"-600# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 3 FT | 49.35 | 23.03 |
| T8A-48 | 3"-150# | 3/4 | 4 | 6 | 45° | 7 1/2 | 4 FT | 60.73 | 28.72 |
| | 3"-300# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 4 FT | 61.23 | 28.97 |
| | 3"-600# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 4 FT | 61.35 | 29.03 |
| T8A-60 | 3"-150# | 3/4 | 4 | 6 | 45° | 7 1/2 | 5 FT | 72.73 | 34.72 |
| | 3"-300# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 5 FT | 73.23 | 34.97 |
| | 3"-600# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 5 FT | 73.35 | 35.03 |
| T8A-72 | 3"-150# | 3/4 | 4 | 6 | 45° | 7 1/2 | 6 FT | 84.73 | 40.72 |
| | 3"-300# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 6 FT | 85.23 | 40.97 |
| | 3"-600# | 7/8 | 8 | 6 5/8 | 22.5° | 8 1/4 | 6 FT | 85.35 | 41.03 |

MODEL DESCRIPTION
T8A-24-A-A

| LENGTH IN INCHES | CONFIGURATION | PICKOFF |
|---|---|---|
| 24 | A = 150# FLG | A = STD RF |
| 36 | B = 300# FLG | B = STD MAG |
| 48 | C = 600# FLG | C = HI-TEMP RF |
| 60 | | D = HI-TEMP MAG |
| 72 | | |

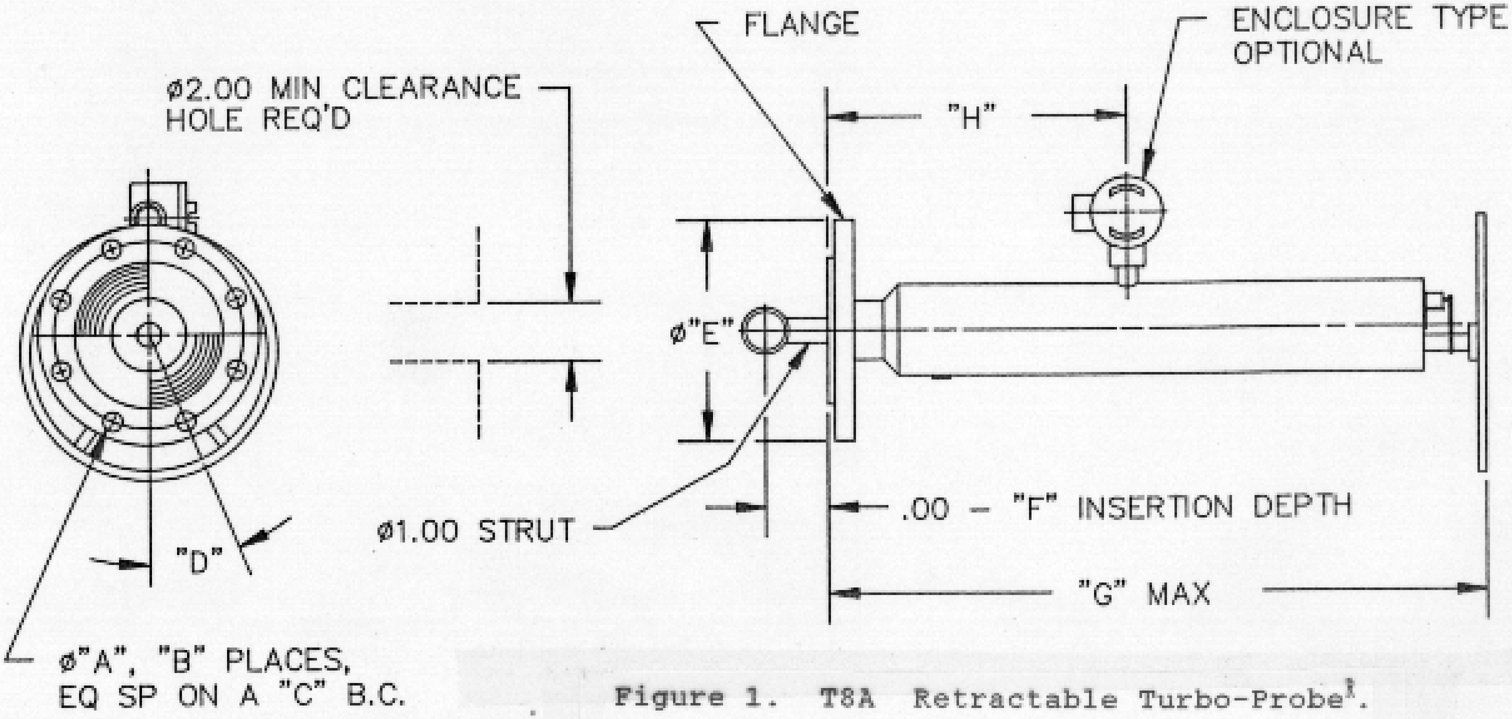


Figure 1. T8A Retractable Turbo-Probe[1].

| MODEL NO | FLANGE | "A" | "B" | "C" | "D" | "E" | "F" | "G" | "H" |
|---|---|---|---|---|---|---|---|---|---|
| T9A-36 | 3-150 | .75 | 4 | 6.00 | 45° | 7.50 | 3" | 48.73 | 22.72 |
| | 3-300 | .88 | 8 | 6.62 | 22.5° | 8.25 | 3" | 49.23 | 22.97 |
| | 3-600 | .88 | 8 | 6.62 | 22.5° | 8.25 | 3" | 49.35 | 23.03 |
| T9A-48 | 3-150 | .75 | 4 | 6.00 | 45° | 7.50 | 4" | 60.73 | 28.72 |
| | 3-300 | .88 | 8 | 6.62 | 22.5° | 8.25 | 4" | 61.23 | 28.97 |
| | 3-600 | .88 | 8 | 6.62 | 22.5° | 8.25 | 4" | 61.35 | 29.03 |
| T9A-72 | 3-150 | .75 | 4 | 6.00 | 45° | 7.50 | 6" | 84.73 | 40.72 |
| | 3-300 | .88 | 8 | 6.62 | 22.5° | 8.25 | 6" | 85.23 | 40.97 |
| | 3-600 | .88 | 8 | 6.62 | 22.5° | 8.25 | 6" | 85.35 | 41.03 |
| T9A-96 | 3-150 | .75 | 4 | 6.00 | 45° | 7.50 | 8" | 108.73 | 52.72 |
| | 3-300 | .88 | 8 | 6.62 | 22.5° | 8.25 | 8" | 109.23 | 52.97 |
| | 3-600 | .88 | 8 | 6.62 | 22.5° | 8.25 | 8" | 109.35 | 53.03 |

MODEL DESCRIPTION
T9A-36-A-A

| LENGTH IN INCHES | CONFIGURATION | PICKOFF |
|---|---|---|
| 36 | A = 150# FLG | A = STD RF |
| 48 | B = 300# FLG | B = STD MAG |
| 72 | C = 600# FLG | C = HI-TEMP RF |
| 96 | | D = HI-TEMP MAG |

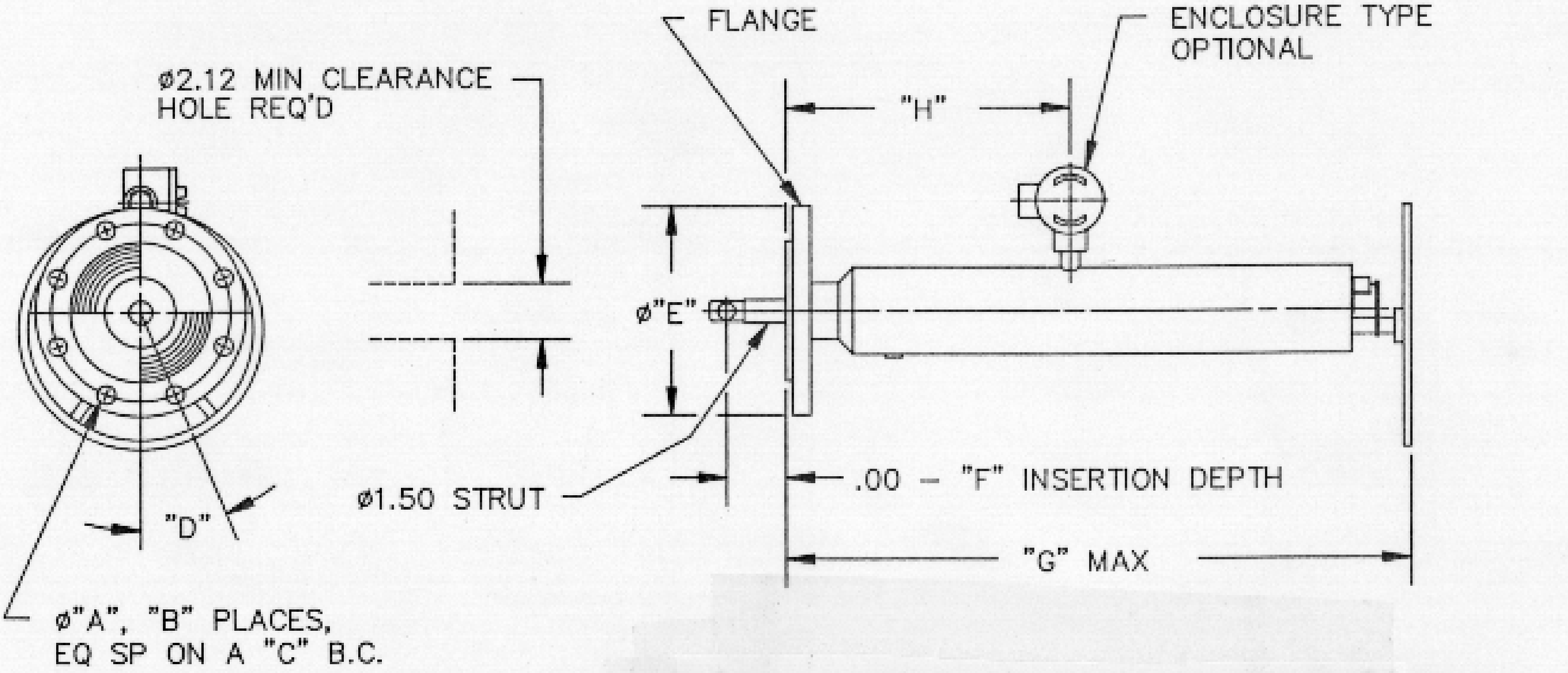


Figure 2. T9A Retractable Turbo-Probe[1].

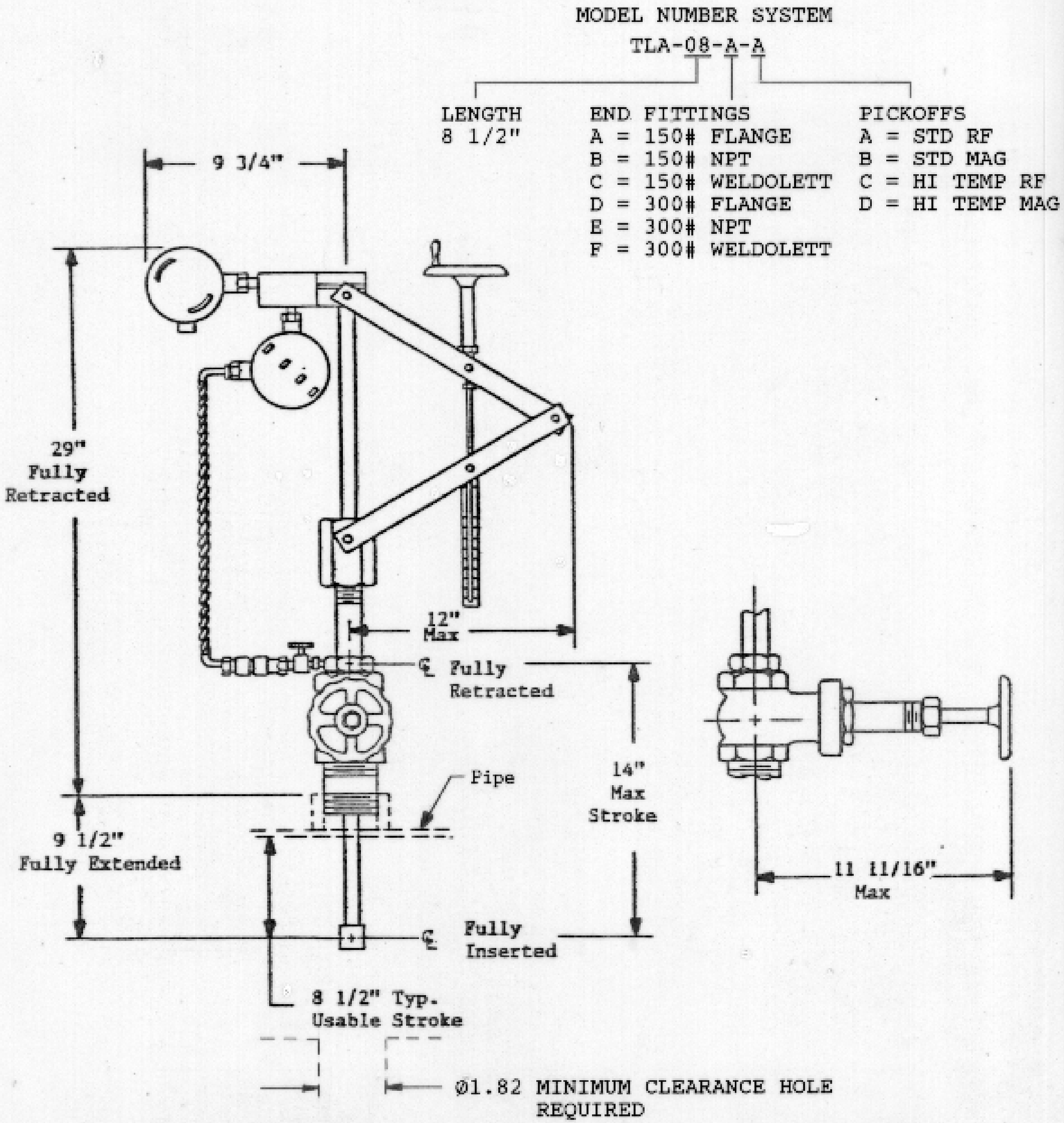
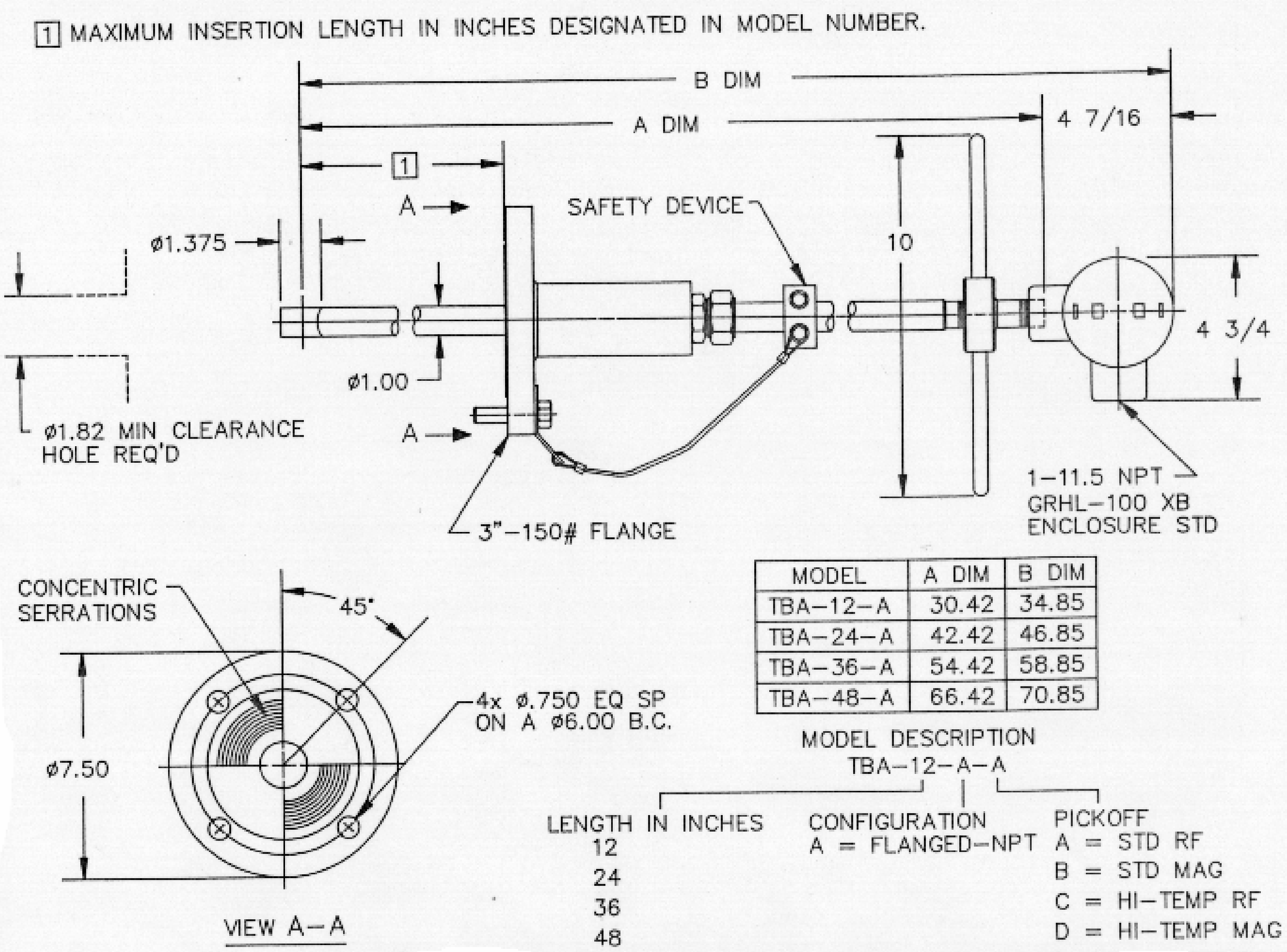


Figure 3. TLA-08-X Low Profile Turbo-Probe®.



| MODEL | A DIM | B DIM |
|---|---|---|
| TBA–12–A | 30.42 | 34.85 |
| TBA–24–A | 42.42 | 46.85 |
| TBA–36–A | 54.42 | 58.85 |
| TBA–48–A | 66.42 | 70.85 |

MODEL DESCRIPTION
TBA–12–A–A

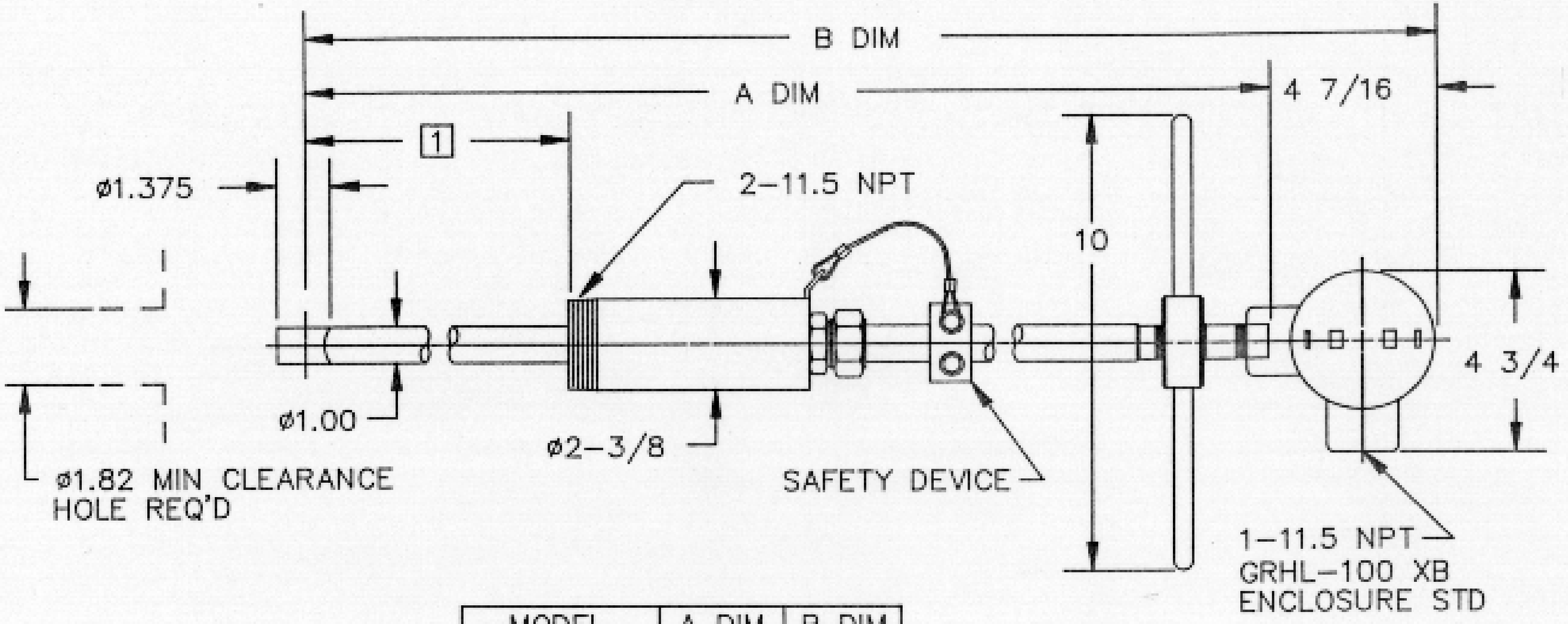
LENGTH IN INCHES
12
24
36
48

CONFIGURATION
A = FLANGED–NPT

PICKOFF
A = STD RF
B = STD MAG
C = HI–TEMP RF
D = HI–TEMP MAG

Figure 4. TBA-XX-A Retractable Turbo-Probe®.

[1] MAXIMUM INSERTION LENGTH IN INCHES DESIGNATED IN MODEL NUMBER.



| MODEL | A DIM | B DIM |
|---|---|---|
| TBA–12–B | 30.42 | 34.85 |
| TBA–24–B | 42.42 | 46.85 |
| TBA–36–B | 54.42 | 58.85 |
| TBA–48–B | 66.42 | 70.85 |

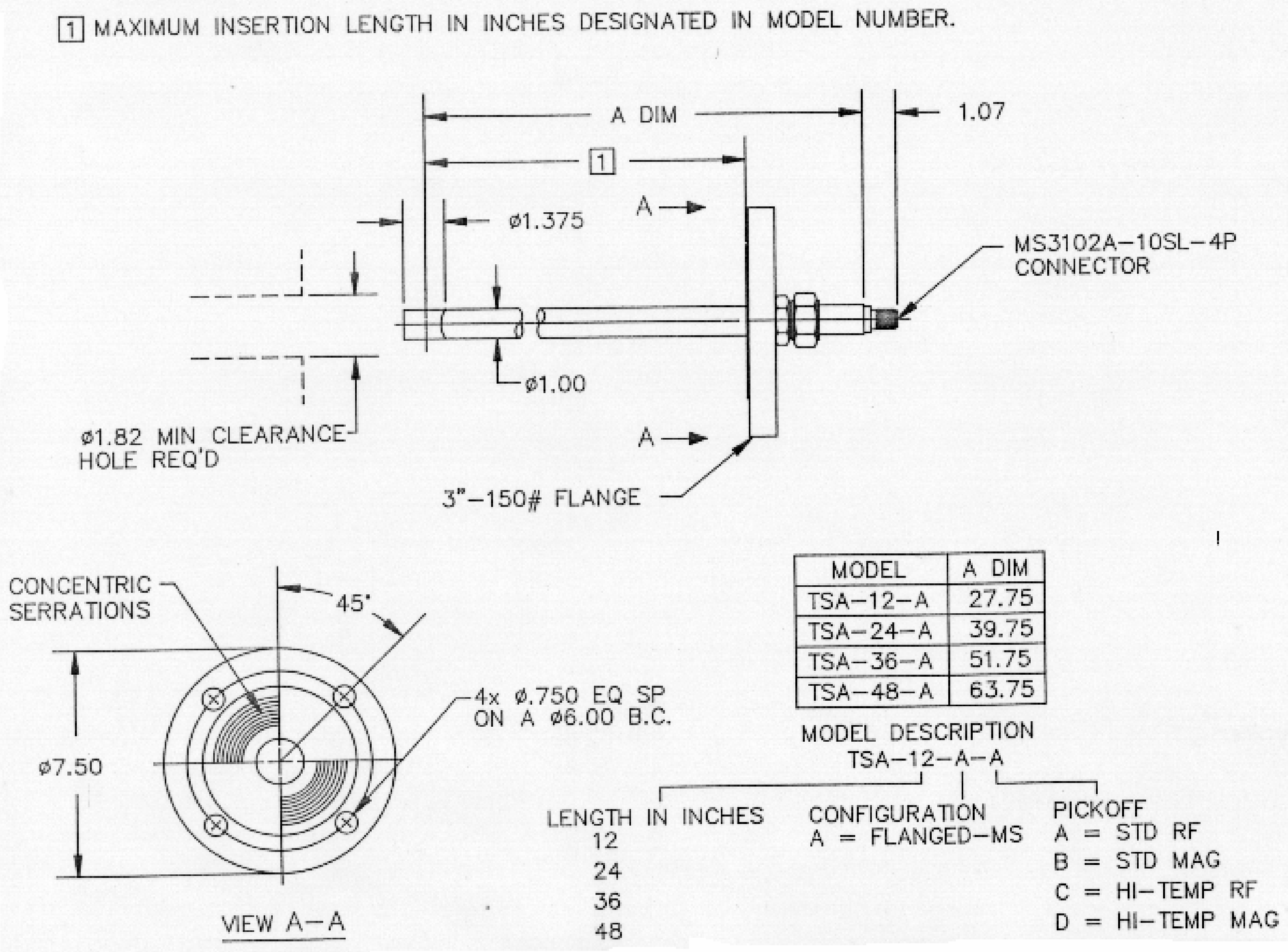
MODEL DESCRIPTION
TBA–12–B–A

LENGTH IN INCHES
12
24
36
48

CONFIGURATION
B = NPT – NPT

PICKOFF
A = STD RF
B = STD MAG
C = HI–TEMP RF
D = HI–TEMP MAG

Figure 5. TBA-XX-B Retractable Turbo-Probe$^{R}$.



| MODEL | A DIM |
|---|---|
| TSA–12–A | 27.75 |
| TSA–24–A | 39.75 |
| TSA–36–A | 51.75 |
| TSA–48–A | 63.75 |

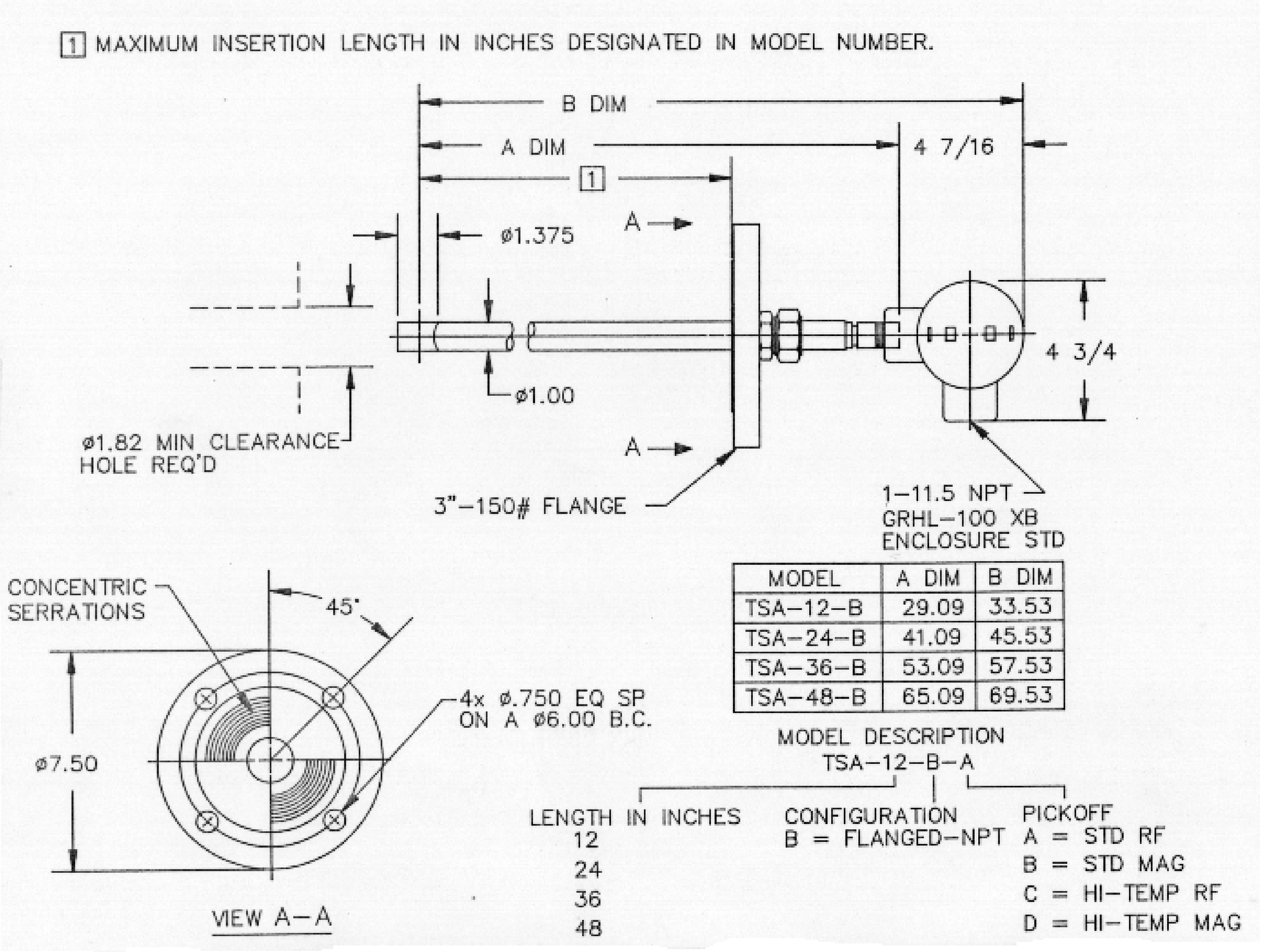
MODEL DESCRIPTION
TSA–12–A–A

LENGTH IN INCHES
12
24
36
48

CONFIGURATION
A = FLANGED–MS

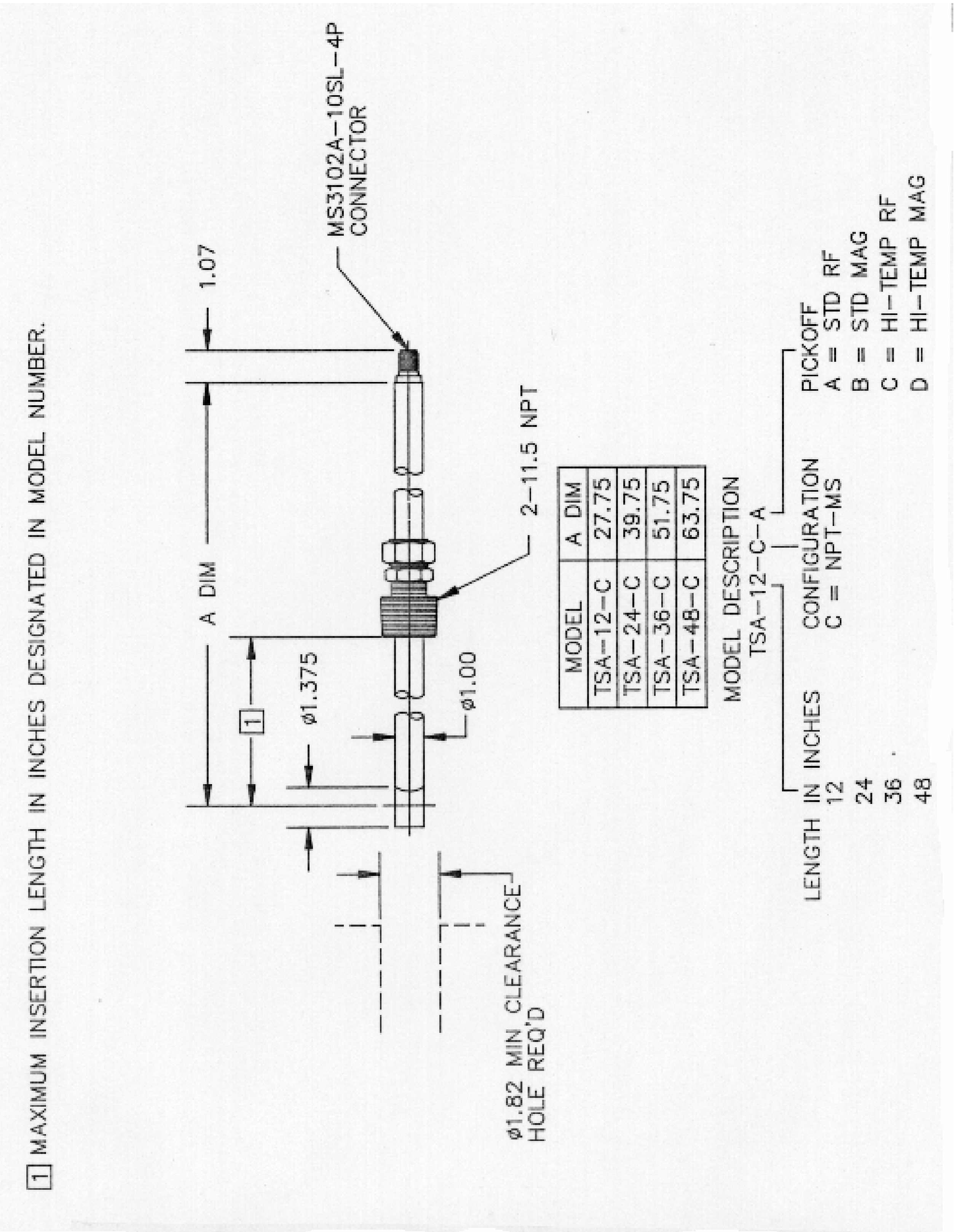
PICKOFF
A = STD RF
B = STD MAG
C = HI–TEMP RF
D = HI–TEMP MAG

Figure 6. TSA-XX-A Retractable Turbo-Probe$^{R}$.



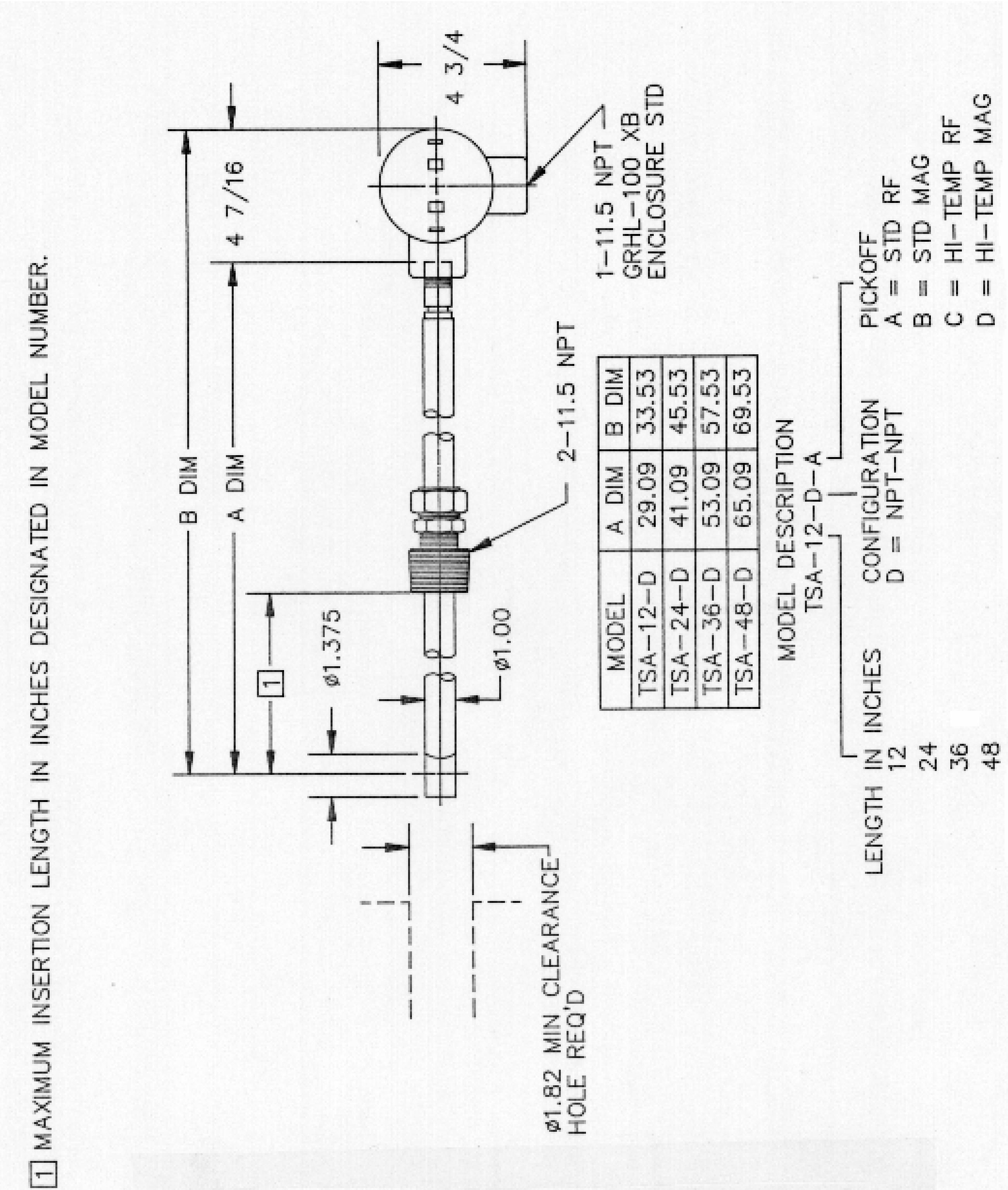
| MODEL | A DIM | B DIM |
|---|---|---|
| TSA–12–B | 29.09 | 33.53 |
| TSA–24–B | 41.09 | 45.53 |
| TSA–36–B | 53.09 | 57.53 |
| TSA–48–B | 65.09 | 69.53 |

Figure 7. TSA-XX-B Retractable Turbo-Probe[1].



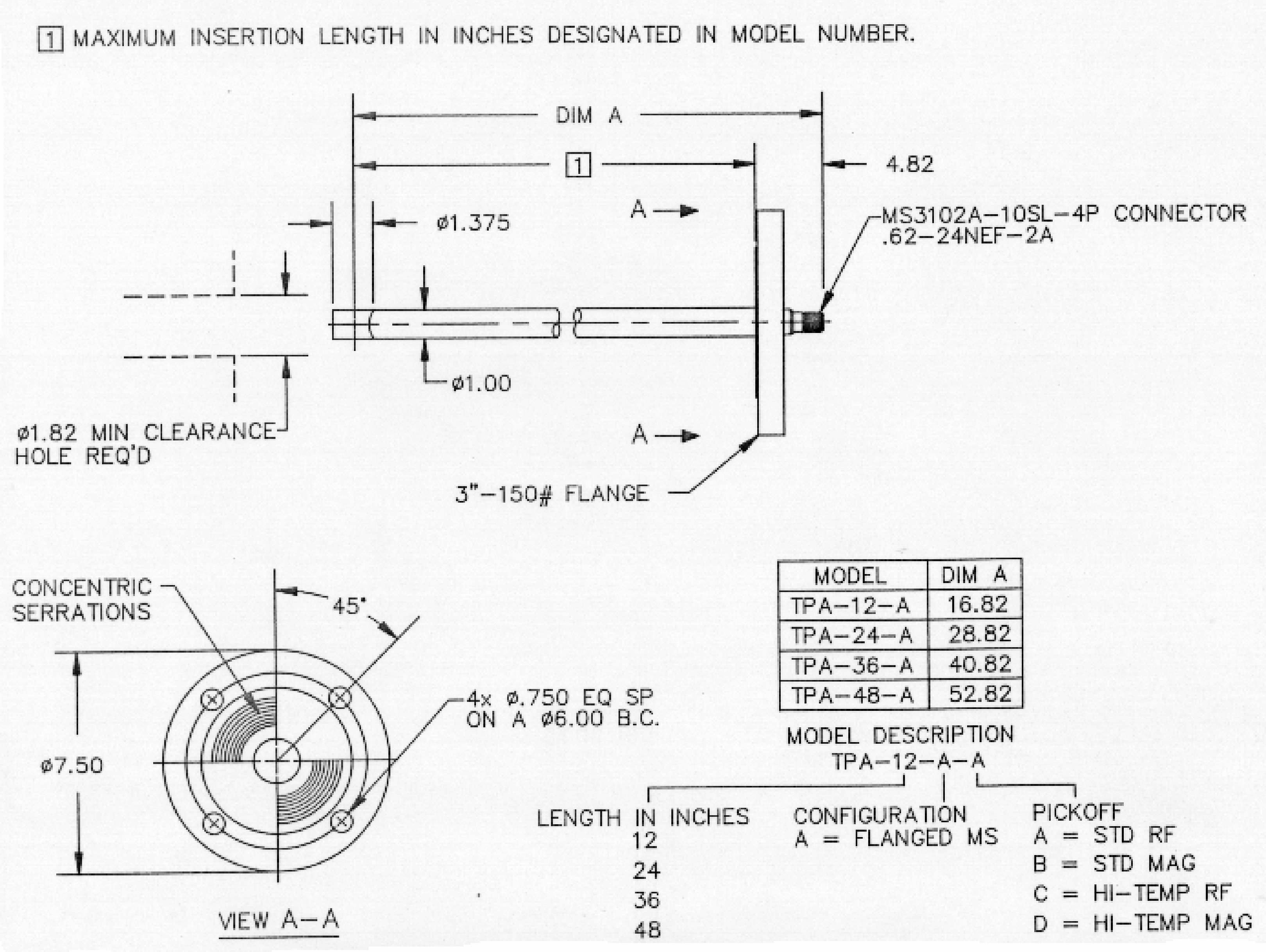
| MODEL | A DIM |
|---|---|
| TSA-12-C | 27.75 |
| TSA-24-C | 39.75 |
| TSA-36-C | 51.75 |
| TSA-48-C | 63.75 |

Figure 8. TSA-XX-C Retractable Turbo-Probe[2].



| MODEL | A DIM | B DIM |
|---|---|---|
| TSA–12–D | 29.09 | 33.53 |
| TSA–24–D | 41.09 | 45.53 |
| TSA–36–D | 53.09 | 57.53 |
| TSA–48–D | 65.09 | 69.53 |

Figure 9. TSA-XX-D Retractable Turbo-Probe®.



| MODEL | DIM A |
|---|---|
| TPA-12-A | 16.82 |
| TPA-24-A | 28.82 |
| TPA-36-A | 40.82 |
| TPA-48-A | 52.82 |

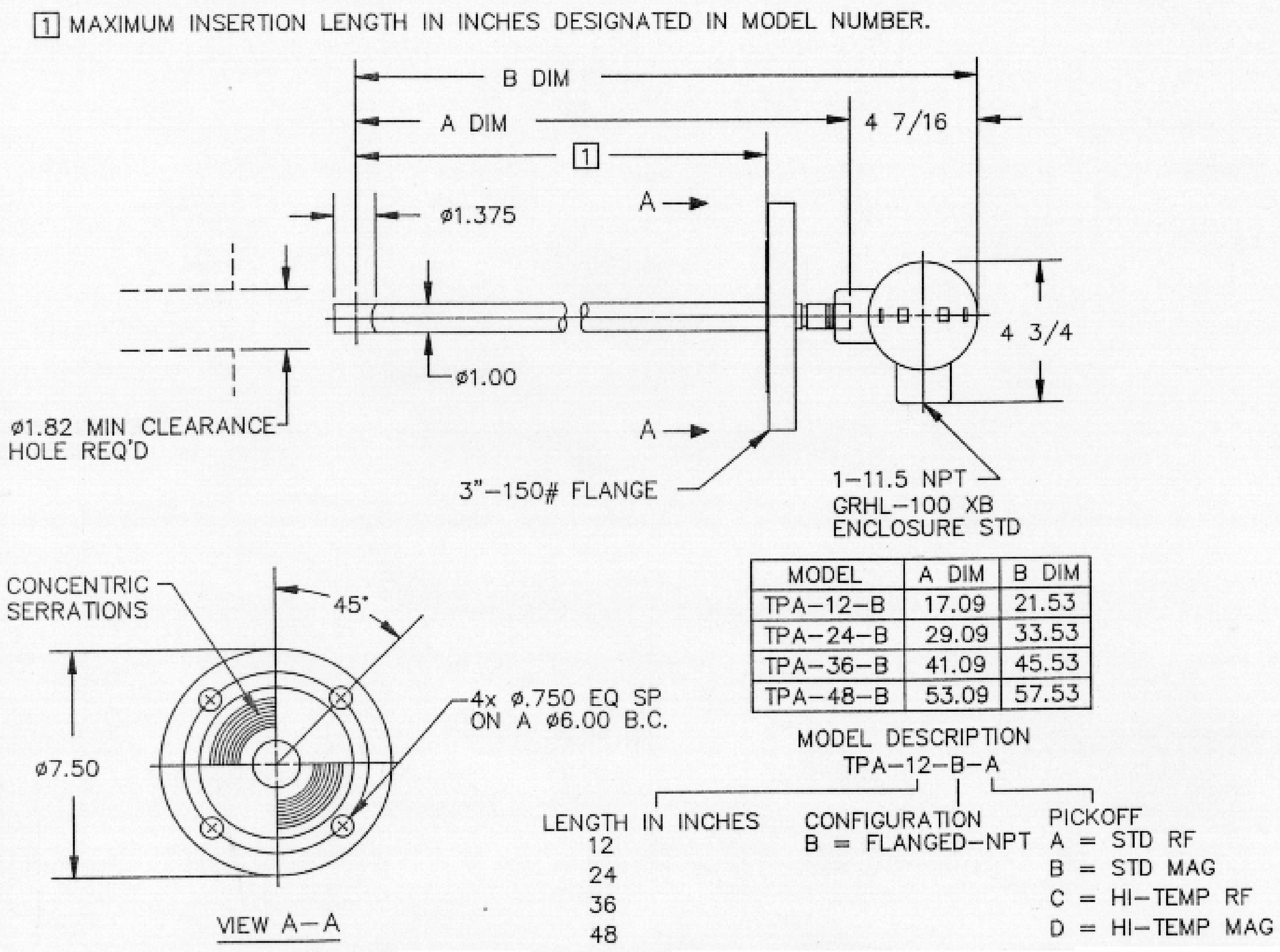
MODEL DESCRIPTION
TPA-12-A-A

LENGTH IN INCHES
12
24
36
48

CONFIGURATION
A = FLANGED MS

PICKOFF
A = STD RF
B = STD MAG
C = HI-TEMP RF
D = HI-TEMP MAG

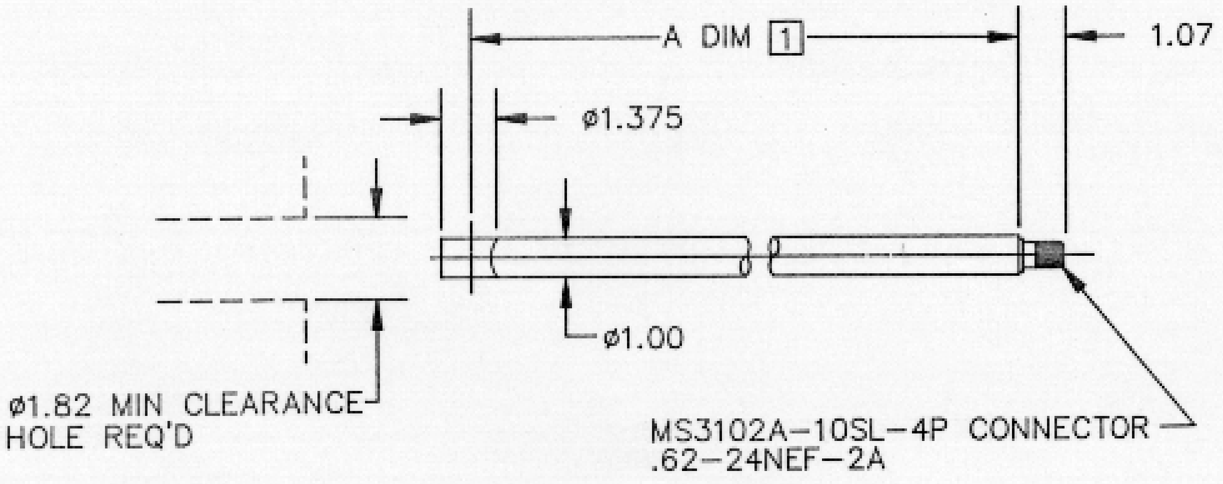
Figure 10. TPA-XX-A Retractable Turbo-Probe®.



| MODEL | A DIM | B DIM |
|---|---|---|
| TPA–12–B | 17.09 | 21.53 |
| TPA–24–B | 29.09 | 33.53 |
| TPA–36–B | 41.09 | 45.53 |
| TPA–48–B | 53.09 | 57.53 |

Figure 11. TPA-XX-B Fixed Turbo-Probe[3].

1 MAXIMUM INSERTION LENGTH IN INCHES DESIGNATED IN MODEL NUMBER.



| MODEL | A DIM |
|---|---|
| TPA–12–C | 15.75 |
| TPA–24–C | 27.75 |
| TPA–36–C | 39.75 |
| TPA–48–C | 51.75 |

MODEL DESCRIPTION
TPA–12–C–A

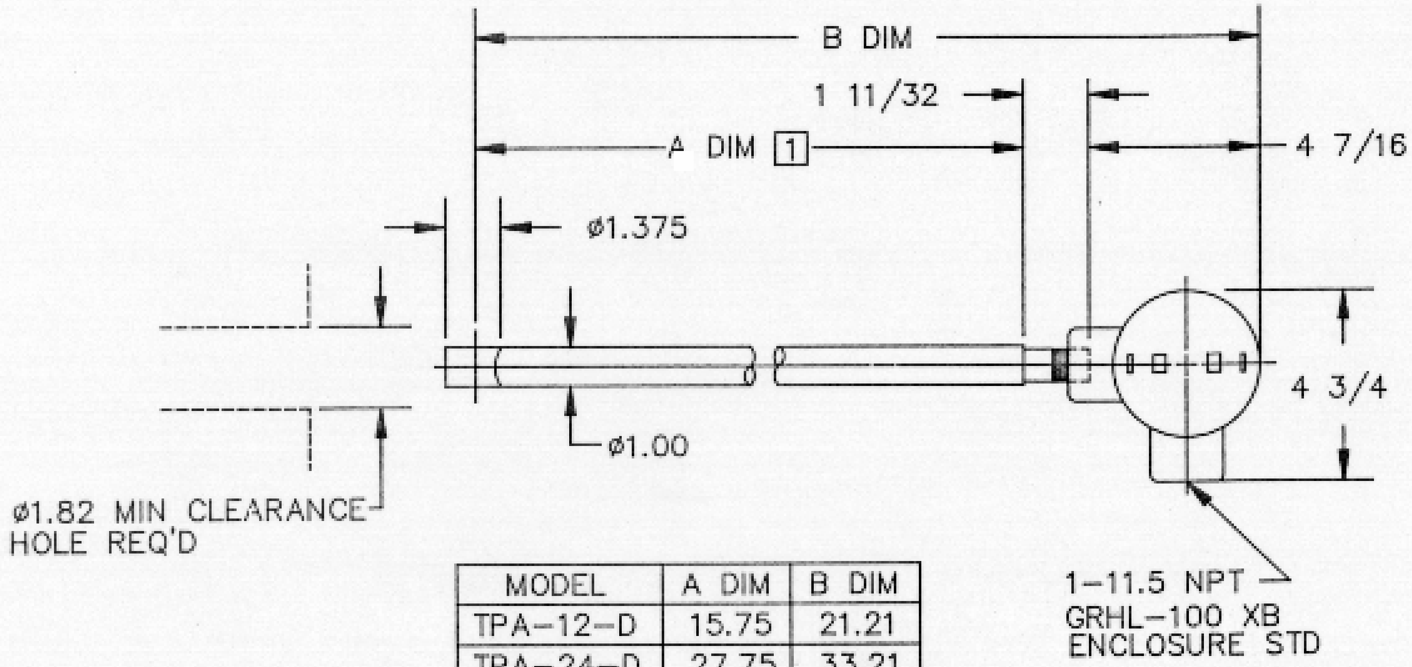
LENGTH IN INCHES
12
24
36
48

CONFIGURATION
C = HANDHELD MS

PICKOFF
A = STD RF
B = STD MAG
C = HI–TEMP RF
D = HI–TEMP MAG

Figure 12. TPA-XX-C Hand-Held Turbo-Probe[1].

1 MAXIMUM INSERTION LENGTH IN INCHES DESIGNATED IN MODEL NUMBER.



| MODEL | A DIM | B DIM |
|---|---|---|
| TPA–12–D | 15.75 | 21.21 |
| TPA–24–D | 27.75 | 33.21 |
| TPA–36–D | 39.75 | 45.21 |
| TPA–48–D | 51.75 | 57.21 |

MODEL DESCRIPTION
TPA–12–D–A

LENGTH IN INCHES
12
24
36
48

CONFIGURATION
D = HANDHELD NPT

PICKOFF
A = STD RF
B = STD MAG
C = HI–TEMP RF
D = HI–TEMP MAG

Figure 13. TPA-XX-D Hand-Held Turbo-Probe[3].

## 4.0 OPERATION

The Turbo-Probe is a velocity sensing device based on the turbine flowmeter operating principle. The theory of operation for this flow measurement concept is explained in great detail in the "Theory of Operation" Section.

## 4.1 TURBO-PROBE$^{R}$ LIQUID CHARACTERISTICS

A Turbo-Probe$^{R}$ will generate electrical pulses at a rate proportional to the velocity or volume of the fluid passing through it, provided that the flow rate is within the design range of the flowmeter.

The relationship between the number of pulses produced by the flowmeter and the velocity or volume of liquid passing through it is called the meter calibration factor. This is usually termed the "K-factor" in technical shorthand. K-factor is a unit normally expressed in terms of pulses per unit volume such as pulses per gallon or pulses per unit velocity such as pulses per foot.

The K-factor for the Turbo-Probe$^{R}$ is determined by calibrating the flowmeter, where a known volume of liquid is passed through the flowmeter in a known period of time. At FTI FLOW TECHNOLOGY, calibration is accomplished with Flow Calibrators traceable to the National Institute of Standards and Technology (NIST), formerly NBS.

The accuracy of the flowmeter is the degree to which the pulses represent the true velocity or volume of liquid passing through the flowmeter over a specified flow rate range. Flow rate is a derived standard since one can obtain traceability to standards, for volume, length or for time, but not for volume-per-unit time or velocity.

The repeatability of a Turbo-Probe$^{R}$ is its ability to reproduce a given signal output or K-factor under identical conditions of flow rate, temperature, viscosity, pressure, and other fluid parameters.

The flowmeter's linearity is the variation experienced from a constant K-factor over a specified flow range. Ideally, a flowmeter should have a constant K-factor over its entire design flow rate range. In the real world, the K-factor changes with flow rate, and the flowmeter's linearity specification describes this deviation from the ideal flat curve.

If the flowmeter is used with liquids having viscosities greater than 3.0 centistoke, the K-factor will change. This effect is sometimes referred to as "viscosity shift". Note that the higher viscosity of the fluid, the greater the viscosity shift effect.

It is possible to compensate for viscosity shift to some extent by multiple viscosity calibrations because it is often desirable to use a flowmeter with liquids that may have widely different viscosities. For this purpose, FTI FLOW TECHNOLOGY can provide a customer with a "Universal Viscosity Curve". One can determine the K-factor of a flowmeter when used with liquids of different viscosities. (Note: Bearing drag may cause meter to deviate from Universal Viscosity Curve at low range.)

The data needed to plot a Universal Viscosity Curve is obtained from a number of "ten-point" calibrations of the flowmeter using fluids of several viscosities. When plotted on a K-factor versus Hz/v (where Hz = frequency in Hz and v = kinematic viscosity in centistoke) curve, the data points will overlap to form a smooth curve.

Using a Universal Viscosity Curve, the performance of a given flowmeter can be determined for an output frequency (Hz) or any viscosity (V) if the Hz/V valve is within the range of data used to generate the curve. One merely finds the Hz/V value and reads the corresponding K-factor directly from the Universal Viscosity Curve. Using a Universal Viscosity Curve will in some cases degrade somewhat the accuracy of the Turbo-Probe$^{R}$.

The data sheet supplied with this flowmeter gives the actual pulses per unit volume or velocity measured at various flow rates during the calibration operation.

The pulses generated by the Turbo-Probe$^{R}$, the GPM flow rates, and the "pulses per gallon" are related as follows:

$$\text{Flow in GPM} = \frac{\text{(pulses/sec or freq/Hz) x 60 sec/min}}{\text{pulses/gal}}$$

$$\begin{array}{l}\text{Pulses per second} \\ \text{(or frequency in Hz)}\end{array} = \frac{\text{GPM x pulses/gal}}{60}$$

The pulses generated by the Turbo-Probe$^{R}$, the GPM flow rates
and the pulses per feet (velocity) are related as follows:

$$\text{Flow in GPM} = \frac{\text{pulses/sec (Hz) X 7.48 ft}^3\text{/gal X 60 sec/min}}{\text{pulses/ft X A (ft}^2\text{)}}$$

A = Flow area (pipe ID)

Mass Flow in pounds per hour (PPH) is a function of the specific gravity:

$$\text{PPH} = \frac{\text{pulses/sec (or freq/Hz)} \times 3600 \times \text{S.G.} \times 8.345}{\text{pulses/gal}}$$

For reference, the approximate relationship between GPM and PPH is:

$$\text{PPH} = \text{GPM} \times 500 \times \text{S.G.} \quad \text{or} \quad \text{GPM} = \frac{\text{PPH}}{500 \times \text{S.G.}}$$

## 4.2 TURBO-PROBE$^R$ GAS CHARACTERISTICS

When measuring liquids, a flowmeter's output is readily related to an absolute standard because the volume of the liquid is essentially independent of its pressure i.e., the liquid is considered to be incompressible in the flow regimes normally covered by Turbo-Probe$^R$. This simple approach cannot be taken when a Turbo-Probe$^R$ measures the flow of a gas. A gas is, by definition, compressible. It changes its volume with changes in both its temperature and its pressure in accordance with the relationships established by Boyle's and Charles' Law.

In order for the actual volume of gas measured by the Turbo-Probe$^R$ to have useful technical meaning, it must be related to an absolute standard: an equivalent volume of gas at a mutually agreed upon standard of temperature and pressure. The "actual" measured volume of gas must be compared against its equivalent "standard" volume of gas.

The standard conditions of pressure and temperature that are used in the United States of America are:

Pressure: 14.7 pounds per square inch absolute (psia)

Temperature: 520 degrees Rankine (60 degrees Fahrenheit)

For proper conversion, an absolute temperature scale must be used.

In the SI system, these standards are cubic meters per hour at $0^oC$ and 1 atmosphere (760 mm of Hg) pressure.

The actual flow rate of gas measured through the turbine flowmeter is expressed in terms of actual cubic feet per minute, ACFM, in the English system. In the metric (SI) system, the unit is cubic meters per hour.

The equivalent flow rate of the gas at standard conditions of temperature and pressure set forth is in terms of standard cubic feet per minute, SCFM, or standard cubic meters per hour, SCMH.

To convert from ACFM to SCFM, we must assume that the gas obeys the Perfect Gas Law.

The following equation is used to convert the actual, measured volume flow rate in ACFM to equivalent of standard conditions of SCFM:

$$Q_s = Q_a \times \frac{P_a}{P_s} \times \frac{T_s}{T_a}$$

where:

$Q_s$ = gas flow rate in SCFM (or $m^3$/sec)

$Q_a$ = gas flow rate as measured in ACFM (or $m^3$/sec)

$P_a$ = measured gas pressure in the flowmeter in psia (or $kg/cm^2$)

$P_s$ = standard pressure = 14.7 psia = 1.0333 $kg/cm^2$

$T_s$ = standard temperature = $520^oR$ = $273.2^oK$

The "short form" of this equation, created by gathering an combining the terms for English system units, can be written as:

$$Q_s = Q_a \times 35.37 \times \frac{P_a}{T_a}$$

$$= 35.37 \frac{Q_a P_a}{T_a}$$

The pressure and temperature measurements made to obtain the data for conversion should be taken immediately downstream of the turbine flowmeter.

## 5.0 INSTALLATION

## 5.1 INSPECTION AND UNPACKING THE TURBO-PROBE$^R$

Spare probe capsules and capsules containing pivot bearings are packaged separately and shipped in the same container as the probe body.

**CAUTION**

**NEVER HANDLE CAPSULES. All handling must be done by holding the shroud of the capsule CONTAINER**

The jewel pivot bearings are very sensitive devices and are very easily damaged. Therefore, special packaging of the probe capsules containing pivot bearings is required.

The Turbo-Probe$^R$ flowmeter should be unpacked carefully and inspected to verify that no damage occurred during shipment. Make certain that the internal parts of the flowmeter are clean and free from packing materials or debris.

**CAUTION**

**A flowmeter is a precision instrument and may be damaged if a high pressure air hose is used for cleaning the meter or for checking the rotation of the rotor. DO NOT exceed 150 RPS on the rotor.**

The shipping crate should be opened carefully to avoid loss of parts, manuals or shipping documents. The Retractable Turbo-Probe$^R$ will be supported horizontally by firm supports to prevent damage to the insertion probe and turbine.

If the Turbo-Probe$^R$ is retractable, extend the probe to full length to inspect for damage during shipment. Blow dry filtered air gently through the turbine capsule to assure that the rotor turns freely and quietly.

## 5.2 MECHANICAL INSTALLATION

There are a number of factors to consider when installing a Turbo-Probe$^R$. The location selected for the installation is important, as is the alignment, insertion depth, and direction of the probe. But even if all of those variables are properly controlled, accurate measurements will not be obtained if the Turbo-Probe$^R$ is damaged during handling. It is an instrument and should be treated accordingly. While the support and mounting structures are generally quite ruggedly built, the rotor and bearing assemblies can be damaged. Dropping the probe may damage the bearings. Blasting the rotor with an air hose to "clean it off" will almost surely destroy them. Also, any deformation of the rotor assembly will cause a change in calibration.

### 5.2.1 Installation Notes

Retractable Turbo-Probes$^R$ may be installed and removed from a line without shutting down the system if an isolation valve is used. This also permits recalibration and maintenance to be accomplished without interrupting the flow. The probe may be installed on a tee without an isolation valve, but this will require shutting down the system for removal and maintenance.

**CAUTION**

**The Turbo-Probe must be FULLY retracted before closing or opening the isolation valve. Failure to comply may cause mechanical damage and void the warranty.**

#### 5.2.1.1 Mounting Fittings

The installation of the Turbo-Probe$^R$ will depend on the mounting fittings. There are two basic types of fittings: flanges and NPT threaded nipple; or the unit may be shipped without any fitting (handheld), allowing the installation of user owned mounting hardware. Compression fittings are available for either configuration, designed to facilitate alignment of the probe capsules (sensing elements) during installation.

The unit may be mounted in a vertical or a horizontal position without affecting the operation of the meter. The probe must be properly aligned so that the arrow on the side of the head points in the direction of the flow and the axis of the rotor is parallel to the flow. Refer to the outline drawings, Figures 1 through 13 for information on the clearance hole required for installation in the process line.

### 5.2.1.2 Flange Mounting

For flange mounting configurations, the Turbo-Probe$^{R}$ is bolted onto the mating flange of the isolation valve, if used, or T-riser, taking care to orient the flow arrow, etched on the flange, with the direction of the flow.

### 5.2.1.3 NPT Threaded Mounting

For NPT threaded mounting, the fitting is screwed into the T-riser and the flow arrow on the strut is oriented in the direction of the flow.

### 5.2.1.4 Jewel Pivot Bearings

When the Turbo-Probe$^{R}$ contains jewel pivot bearings, the probe capsule is packaged separately. Therefore, the following installation instructions should be followed carefully:

1. Break the seal between the cover and the shroud of the capsule container.
2. Remove the cover (smaller of two (2) pieces of the capsule container).
3. Insure that the flow direction arrow on the capsule containing the shroud points in the same direction as the arrow on the capsule housing on the probe.
4. Line up the capsule mounting hole with the holes on the capsule body of the probe.
5. Insert exposed end of the capsule into the capsule housing. This can be accomplished easily by holding the capsule at approximately 30 degrees to the capsule housing to originate the insertion.
6. Push the shroud/capsule combination, until the shroud rests on the capsule housing. (See Figure 14 for Capsule Installation).
7. Use the T-shaped tool (shipped with unit) to push the partially inserted capsule into the capsule housing.
8. Check for proper alignment of holes in the capsule to the mounting holes of the capsule housing. If required, carefully align <u>without</u> touching the rotor in any way. Fasten the two (2) screws.

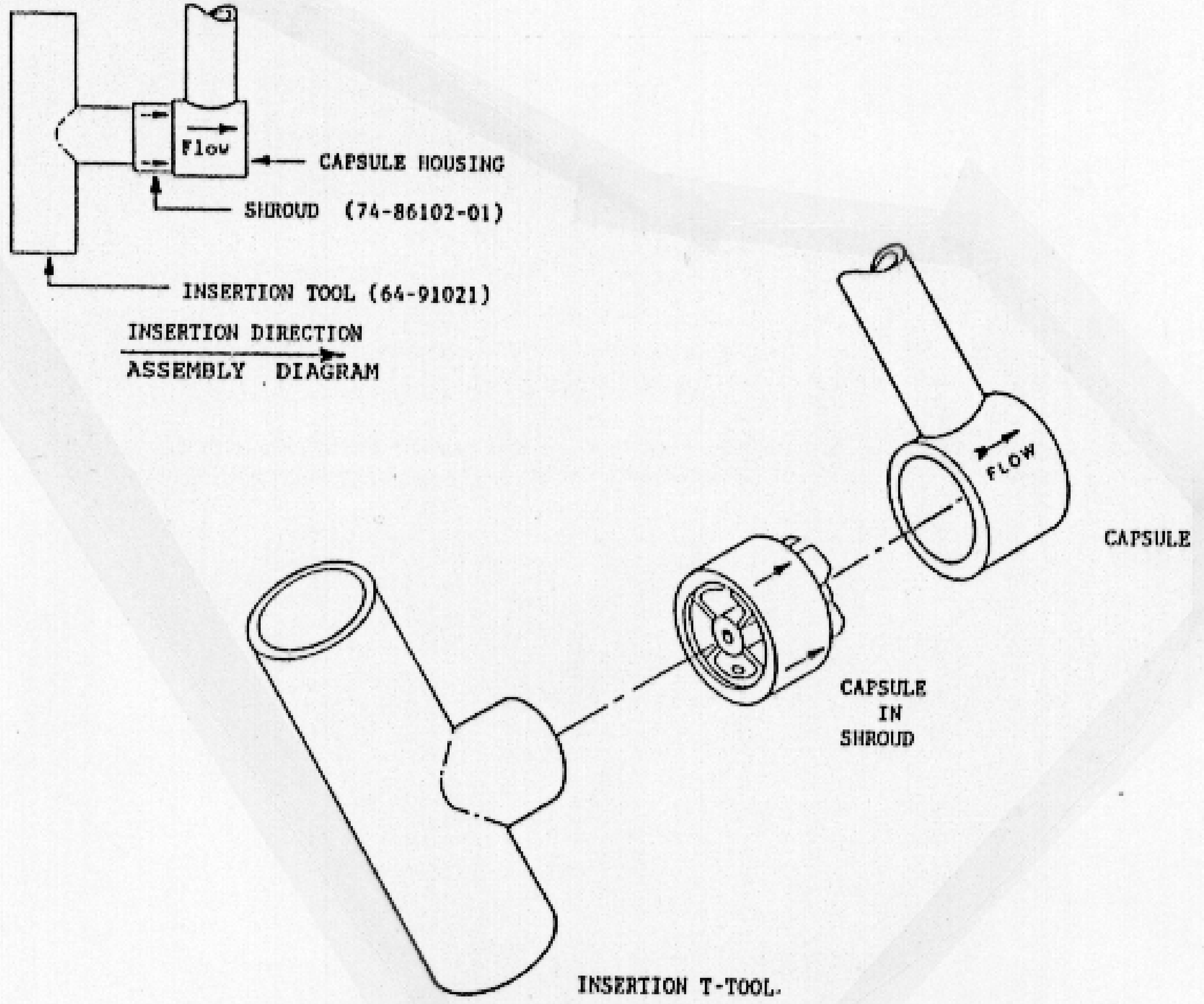


Figure 14. Capsule Installation.

### 5.2.2 Alignment

The rotor axis must be aligned so that it is parallel with the axis of the pipe for accurate measurement. Misalignment will either increase of decrease the probe output for the same flow velocity. The probe cannot be rotated to achieve maximum output for alignment purposes since the effect of such rotations are not symmetrical like they are for a pivot tube. Certain types of FTI FLOW TECHNOLOGY's Turbo-Probes$^R$ are designed so that proper alignment is easily maintained at all times by observing the direction of the flow arrow. In the TB and TS versions, the downstream side of the top of the probe strut is marked with a scribe or a dimple.

### 5.2.3 Direction

Most Turbo-Probes$^R$ appear symmetric and can easily be installed backwards, if a conscious effort is not made to preserve directional alignment. Geometric differences not visible to the naked eye can cause differences in performance in the two directions. If it is planned to use the meter for measurement in both directions, it should be calibrated in the same way. Pivot bearings are unidirectional. Flow in the reverse direction will result in bearing damage (bidirectional pivot bearings are available for some applications. Consult Factory).

### 5.2.4 Flow Disturbances

The location chosen for mounting the probe is very important. Flow disturbances upstream of the probe location due to valves, elbows, or other obstructions will produce non-axial velocity vectors (swirl) and disturbances of the velocity profile within the pipe that will make it impossible to relate the velocity sample measured to the average velocity present in the pipe.

The length of straight line required to establish steady and fully developed flow depends on the conditions present in the line. Some references recommend a minimum of 100 pipe diameters of straight pipe upstream when swirl is present. In all cases, the straight pipe section upstream should never be less than 25 pipe diameters. The length of the downstream straight pipe section should not be less than half of the upstream section. Since in many installations, the length of upstream straight sections is limited, use of flow conditioners (etoile, tube bundles etc.) is recommended.

### 5.2.5 Insertion Depth

The radial position of the turbine measuring element within the pipe is also critical. Factors to consider in selecting this position are discussed in the "Theory of Operation" section. For installations in 6" or larger lines, the turbine measuring element should be located at a distance equal to 12% of the pipe inside diameter, away from the pipe wall. For installation in pipes of less than 6 inches in diameter, best accuracy will be achieved by positioning the turbine sensing element at the center of the pipe. See Theory of Operation, Section 8, for more information.

### 5.2.6 Safety

Never exceed the pressure rating of the Turbo-Probes$^R$.

Internal pressure in the line will create an outward force on the probe strut. For the TB and the TS actuator models, the Swagelok$^R$ nuts must always be tightened securely when the line is under pressure. The TB versions are supplied with a safety block. Insure that it is installed properly for these models.

## 5.3 ELECTRICAL INSTALLATION

For units with enclosures mounted on them, electrical connections are made to the terminal strip in the explosion-proof enclosure. There are two (2) terminal connections to be made from the pickoff leads. For units with a 2 pin MS-type connector, electrical connections are made by attaching the mating connector.

### 5.3.1 Magnetic and Modulated Pickoffs

The Turbo-Probe$^R$ uses either a magnetic or a modulated carrier pickoff.

#### 5.3.1.1 Magnetic Pickoff

The magnetic pickoff output is a low level signal that ranges from 10 mV to several volts peak-to-peak. The signal conditioner, also called a pulse converter, is needed to convert the pickoff low level signal to a 10 V peak-to-peak pulse signal suitable for process instrumentation.

#### 5.3.1.2 Modulated Carrier (RF) Pickoff

The Modulated Carrier (RF) pickoff must be installed with an appropriate signal conditioner (Consult Sales Rep or Factory). The signal conditioner is needed to convert the modulated carrier signal to a 10 V peak-to-peak pulse signal suitable for process instrumentation.

#### 5.3.1.3 Pickoff Connections to Electronics

Figure 15 shows pickoff connection to the electronics and Figure 16 shows the magnetic pickoff connections. The following rules must be observed for proper operation:

1. Do not mount the Turbo-Probe$^{R}$ close to electrical equipment (motors, relays, etc.).

2. Use a twisted and shielded cable (Belden 8761 or equivalent) for the pickoff/amplifier connection.

3. Mount the amplifier as close as possible to the probe. For Magnetic pickoffs, up to 1000 feet (300 meters) of Belden 8761 (or equivalent) is the maximum cable length in an electrically noise free environment. For Modulated Carrier (RF) pickoffs, cable length may not exceed 100 feet (30 meters).

4. The conduit for the pickoff cable must not be shared with other services (cables). A #14 AWG (or larger diameter) ground wire connected from the amplifier ground to the probe body or pipe may reduce electrical noise. Earth ground attached to the amplifier ground may reduce the noise.

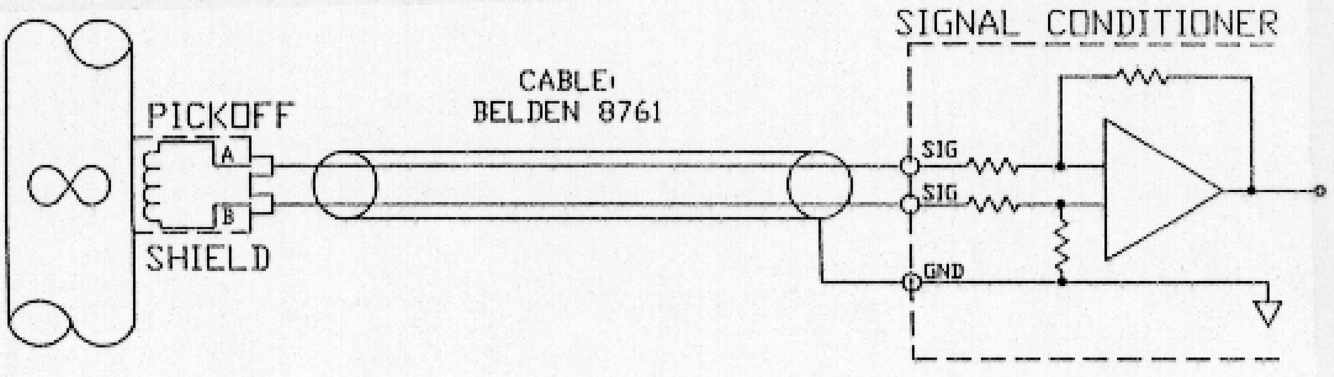


Figure 15. RF Pickoff Connection to Electronics

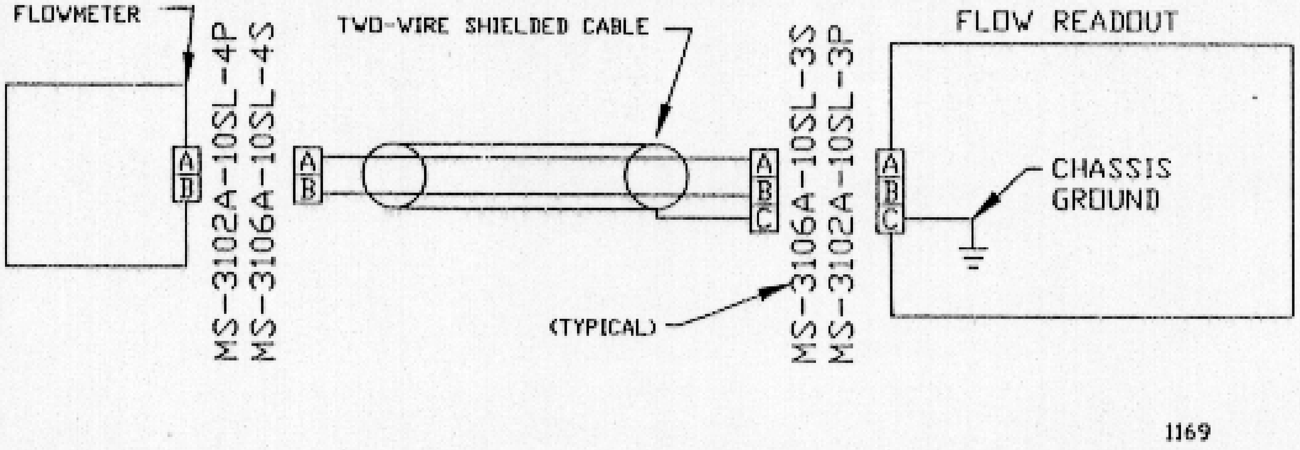


Figure 16. Magnetic Pickoff Connections.

# 6.0 SPECIFICATIONS AND OPTIONS

A large number of actuator assembly and capsule element combinations are available. For specifications and options consult Sections, 6.2.1 through 6.2.5, for the specific models.

| | |
|---|---|
| Temperature Range | -60$^{o}$F to +400$^{o}$F |
| Optional | -45$^{o}$F to +750$^{o}$F |

# 6.1 TURBO-PROBE ACTUATORS

The relevant specifications and model numbering system for each available actuator are given below.

TABLE 1

PICKOFF CHARACTERISTICS

| TYPE OF PICKOFF | PICKOFF RESISTANCE | PICKOFF OUTPUT LEVEL. | FREQUENCY RANGE |
|---|---|---|---|
| Magnetic (Inductive or Reluctance) 450 °F | 2000 to 3000 ohms depending upon the ambient temperature and model number. | Average 30 mV peak to peak for frequencies at the lowest flow rate within the normal 10:1 range. | 10 to 10 KHz depending upon size and calibration of the flowmeter. Refer to the calibration sheet that accompanies the flowmeter. |
| Magnetic, High Temperature (Reluctance) 750°F | 100 to 200 ohm depending upon the ambient temperature and model number | | |
| Modulated Carrier (Flow Technology RF Amplifier) [1] 400°F | 10 to 16 ohms | No output unless connected to a CA03 amplifier. A 10 Volt pulse at the flowmeter frequency when the amplifier is connected and operating. | 0.5 to 3500 Hz depending upon the size and calibration of the flowmeter. Refer to the calibration data sheet. |
| Modulated Carrier High Temperature (Flow Technology RF Amplifier) 800°F | 3 to 5 ohms | | |

---

[1] *Electronics must be protected from excessive heat.*

### 6.1.1 T8 and T9 Models

T __ A - __ __ - __ - __

CONFIGURATION (1)
8 - 1" STRUT
9 - 1.5" STRUT

REVISION DESIGNATOR

INSERT LENGTH (inches) (2)
24 (T8 only)
36
48
60 (T8 only)
72
96 (T9 only)

MOUNTING CONFIGURATION (3)
A - 150 # ANSI FLANGE
B - 300 # ANSI FLANGE
C - 600 # ANSI FLANGE

PICKOFF (4)
A - STANDARD RF
B - STANDARD MAG
C - HI-TEMP RF
D - I-TEMP MAG

**T8 and T9 Notes:**

(1) The 1.5" Strut is used in application where longer insertion depths and measurement of high velocity and dense fluids is required. Consult factory for applications information,

(2) Maximum insertion length. Minimum insertion length is determined by the user's installation configuration.

(3) Maximum pressure rating of the Turbo-Probe is determined by the ANSI flange rating as follows:

150 # - 275 psi (19 bar)
300 # - 720 psi (50 bar)
600 # - 1440 psi (99 bar)

(4) See Table 1, Pickoff Characteristics for pickoff specifications.

### 6.1.2 TL Model

TLA - 0 8 - __ - __

REVISION DESIGNATOR

INSERTION LENGTH (1)
8.5 inches

PICKOFF (4)
A - STANDARD RF
B - STANDARD MAG
C - HI-TEMP RF
D - HI-TEMP MAG

MOUNTING CONFIGURATION (2)
A - 150# ANSI FLANGE
B - 150# NPT
C - 150# WELDOLET (3)
D - 300# ANSI FLANGE
E - 300# NPT
F - 300# WELDOLET (3)

**TL NOTES:**

(1) Maximum insertion length. Minimum insertion length is determined by the user's installation configuration.

(2) Maximum pressure rating of the Turbo-Probe is determined by the ANSI flange rating as follows:

150# - 275 psi (19 bar)
300# - 720 psi (50 bar)

(3) The size of the process line will influence the selection of the weldolet. Consult the factory for application information.

(4) See Table 1, Pickoff Characteristics for pickoff specifications.

### 6.1.3 TB Model

TBA - __ __ - __ - __

REVISION DESIGNATOR

INSERTION LENGTH (1)
12 Inches
24 Inches
36 Inches
48 Inches

MOUNTING CONFIGURATION (2)(3)
A - 150# FLANGE, NPT PICKOFF
B - 150# 2" NPT, NPT PICKOFF

PICKOFF (4)
A - STANDARD RF
B - STANDARD MAG
C - HI-TEMP RF
D - HI-TEMP MAG

**TB NOTES:**

(1) Maximum insertion length. Minimum insertion length is determined by the user's installation configuration.

(2) Maximum pressure rating of the turbo-probe is determined by the ANSI flange rating as follows:

150 # - 275 psi (19 bar)

(3) The pickoff end connection is an NPT that allows mounting of a condulet for explosion proof applications.

(4) See Table 1, Pickoff characteristics for pickoff specifications.

### 6.1.4 TS Model

TSA - _ _ - __ - __

REVISION DESIGNATOR

INSERTION LENGTH (1)
12 Inches
24 Inches
36 Inches
48 Inches

PICKOFF (4)
A - STANDARD RF
B - STANDARD MAG
C - HI-TEMP RF
D - HI-TEMP MAG

MOUNTING CONFIGURATION (2)(3)
A - 150# FLANGE, MS PICKOFF
B - 150# FLANGE, NPT PICKOFF
C - NPT, MS PICKOFF
D - NPT, NPT PICKOFF

**TS NOTES:**

(1) Maximum insertion length. Minimum insertion length is determined by the user's installation configuration.

(2) Even though 150 # flanges are used in the A and B mounting configurations, maximum pressure rating for all TS turbo-probe is 50 psi (3.5 Bar).

(3) The pickoff end connection is an MS or NPT for mounting a condulet is required for explosion proof applications.

(4) See Table 1, Pickoff Characteristics for pickoff specifications.

### 6.1.5 TP MODEL

TPA - _ _ - __ - __

REVISION DESIGNATOR

INSERTION LENGTH (1)
12 Inches
24 Inches
36 Inches
48 Inches

PICKOFF (4)
A - STANDARD RF
B - STANDARD MAG
C - HI-TEMP RF
D - HI-TEMP MAG

MOUNTING CONFIGURATION (2)(3)
A - 150 # FLANGE, MS PICKOFF
B - 150 # FLANGE, NPT PICKOFF
C - HANDHELD, MS PICKOFF
D - HANDHELD, NPT PICKOFF

**TP NOTES:**

(1) Maximum insertion length. Minimum insertion length is determined by the user's installation configuration.

(2) Maximum pressure rating of the flanged turbo-probe is determined by the ANSI flange rating as follows:

150 # - 275 psi (19 bar)
pressure rating is not applicable for the handheld versions.

(3) The pickoff end connection is an MS or NPT for mounting a condulet is required for explosion proof applications.

(4) See Table 1, Pickoff Characteristics for pickoff specifications.

### 6.2 CAPSULE (FLOW SENSOR) SPECIFICATIONS

Section 3.1 contains an explanation of the model numbering system, while Table 2 contains in detail the specifications of the various versions of the Turbo-Probe capsules. Additional specifications are listed below:

| | |
|---|---|
| Viscosity Range: | Liquid- 0.1 To 100 centistokes depending on flow range. As the viscosity increases the rangeability is sharply decreased. |
| : | Gas - Consult factory. |
| Pressure Drop: | Negligible. |
| Temp. Range: | -60 to +400°F (-450 to +750°F optional). Refer to Table 3 Bearing Application Guide. |

# TABLE 2

## TURBO-PROBE® CAPSULE FLOW RANGE CHART FOR LIQUID SERVICE

JEWEL BEARINGS[7]

| | | STD (10:1) RANGE (FPM)[6] | | EXTENDED RANGE (FPM)[6] | |
|---|---|---|---|---|---|
| MODEL NUMBER[2] | LINEARITY[1,5] (± % FS) | RF PICKOFF | MAG PICKOFF | RF PICKOFF | MAG PICKOFF |
| CA-HC-43-2L | 2.0 | 8-80 | N/A | 6-100 | N/A |
| CA-HC-43-1L | 2.0 | 30-300 | N/A | 10-300 | N/A |
| CA-HC-35-1L | 2.0 | 60-600 | 120-600 | 25-1000 | 120-1000 |
| CA-HC-30-1L | 2.0 | 120-1200 | 150-1200 | 60-1500 | 150-1500 |
| CA-HC-20-1L | 1.5 | 180-1800 | 180-1800 | 90-2000 | 180-2000 |
| CA-HC-10-1L | 1.5 | 300-3000 | 300-3000 | 120-3000 | 300-3000 |
| CA-HC-05-1L | 1.5 | 600-6000 | 600-6000 | 240-6000 | 600-6000 |

BALL BEARINGS

| | | STD (10:1) RANGE (FPM)[6] | | EXTENDED RANGE (FPM)[6] | |
|---|---|---|---|---|---|
| MODEL NUMBER[2] | LINEARITY[1,5] (± % FS) | RF PICKOFF | MAG PICKOFF | RF PICKOFF | MAG PICKOFF |
| CA-EA-43-4L | 2.0 | 10-100 | N/A | 10-1200 | N/A |
| CA-EA-43-3L | 2.0 | 30-300 | N/A | 10-1200 | N/A |
| CA-EA-43-2L | 2.0 | 60-600 | 120-600 | 10-1200 | 120-1000 |
| CA-EA-43-1L | 2.0 | 120-1200 | 120-1200 | 10-1200 | 120-1200 |
| CA-EA-20-1L | 1.5 | 180-1800 | 180-1800 | 120-2200 | 180-2200 |
| CA-EA-13-1L | 1.5 | 300-3000 | 300-3000 | 150-3500 | 300-3500 |
| CA-EA-07-1L | 1.5 | 600-6000 | 600-6000 | 300-6000 | 600-6000 |

*NOTE: THIS TABLE ALSO INCLUDES HA CONSTRUCTION/MATERIAL CODE SEE TABLE 3

JOURNAL BEARINGS

| | | STD (10:1) RANGE (FPM)[6] | | EXTENDED RANGE (FPM)[6] | |
|---|---|---|---|---|---|
| MODEL NUMBER[2] | LINEARITY[1,5] (± % FS) | RF PICKOFF | MAG PICKOFF | RF PICKOFF | MAG PICKOFF |
| CA-HG-43-4L | 2.0 | 15-150 | 120-1200 | 15-1200 | N/A |
| CA-HG-43-3L | 2.0 | 30-300 | 120-1200 | 15-1200 | N/A |
| CA-HG-43-2L | 2.0 | 60-600 | 120-1200 | 15-1200 | N/A |
| CA-HG-43-1L | 2.0 | 120-1200 | 120-1200 | 15-1200 | 120-1000 |
| CA-HG-20-1L | 1.5 | 180-1800 | 180-1800 | 150-2200 | 180-2200 |
| CA-HG-13-1L | 1.5 | 300-3000 | 300-3000 | 200-3500 | 300-3500 |
| CA-HG-07-1L | 1.5 | 600-6000 | 600-6000 | 400-6000 | 600-6000 |

*NOTE: THIS TABLE ALSO INCLUDES HD CONSTRUCTION/MATERIAL CODE SEE TABLE 3

REPEATABILITY[1] = ± 0.25%

TABLE 2 (Continued)

**TURBO-PROBE® CAPSULE FLOW RANGE CHART FOR GAS SERVICE**

JEWEL BEARINGS [7]

| | | STD (10:1) RANGE (FPM) [6] | | EXTENDED RANGE (FPM) [6] | |
|---|---|---|---|---|---|
| MODEL NUMBER [2] | LINEARITY [1] [5] (± % FS) | RF PICKOFF | MAG PICKOFF | RF PICKOFF | MAG PICKOFF |
| CA-HC-43-1G | 11.0 | 90-600 | N/A | 90-1000 | N/A |
| CA-HC-30-1G | 7.0 | 120-1200 | 200-1200 | 100-1500 | N/A |
| CA-HC-20-1G | 5.0 | 180-1800 | 200-1800 | 125-2000 | N/A |
| CA-HC-10-1G | 5.0 | 300-3000 | 400-3000 | 150-4000 | N/A |
| CA-HC-05-1G | 4.0 | 600-6000 | 600-6000 | 300-6000 | N/A |
| CA-HC-03-1G | 4.0 | 1200-12000 | 1200-12000 | 600-12000 | N/A |

BALL BEARINGS

| | | STD (10:1) RANGE (FPM) [6] | | EXTENDED RANGE (FPM) [6] | |
|---|---|---|---|---|---|
| MODEL NUMBER [2] | LINEARITY [1] [5] (± % FS) | RF PICKOFF | MAG PICKOFF | RF PICKOFF | MAG PICKOFF |
| CA-EA-43-2G | 3.0 | 180-1800 | N/A | N/A | N/A |
| CA-EA-43-1G | 2.0 | 300-3000 | 400-3000 | 300-4000 | N/A |
| CA-EA-20-1G | 2.0 | 600-6000 | 600-6000 | 500-6000 | N/A |
| CA-EA-13-1G | 2.0 | 1200-12000 | 1200-12000 | 1000-12000 | N/A |
| CA-EA-07-1G | 2.0 | 1800-18000 | 1800-18000 | 1500-18000 | N/A |

* NOTE: THIS TABLE ALSO INCLUDES HA CONSTRUCTION/MATERIAL CODE SEE TABLE 3

REPEATABILITY [1] = ±0.25%

[1] Specifications valid for normal 10:1 range only.

[2] Blade angle.

[3] Special applications only. Consult Engineering.

[4] Best effort only.

[5] Worst case linearity.

[6] Output level at the low extended range may be below 30mV peak-to-peak when magnetic pickoffs are used (10 mV peak-to-peak minimum).

[7] A maximum frequency of 1250 Hz is acceptable for jewel bearing Turbo-Probes. Higher frequencies (not to exceed 1400 Hz) are allowable for special applications.

# TABLE 3

## CAPSULE MODEL NUMBERING SYSTEM

CA -_ _ -_ _ - _ _ -_ _

REVISION DESIGNATOR

CONSTRUCTION AND BEARING MATERIAL
- EA - Ball Bearing
  - 316, 430F Rotor
- HD - Carbide Journal
  - 316, 17-4 Rotor
- HC - Jewel Pivot
  - 316, 17-4 Rotor
- HA - Ball Bearing
  - 316, 17-4 Rotor
- HG - Ceramic Journal
  - 316, 17-4 Rotor

BLADE ANGLE
- XX - See Table 2

RANGE NUMBER
- X - See Table 2

FLUID TYPE
- L - Liquid
- G - Gas

CALIBRATION
- XX - See Table 5

### 6.2.1 Construction

FTI FLOW TECHNOLOGY's standard materials of construction for all wetter surfaces are 300 series stainless steel. The rotor is constructed of 17-4 stainless steel. For retractable probes, the seals are Graphite-Teflon.

The TL series includes brass in the list of material exposed to the fluid being metered.

### 6.2.2 Bearing

Ball, jewel pivot and journal bearings are available for liquid service. Ball and jewel pivot only are available for gas service. Table 4 provides more information on bearing applications. Table 5 lists the available configurations.

**TABLE 4**
**BEARING APPLICATION GUIDE**

| BEARING TYPE | SERVICE | CORROSION RATING | TEMPERATURE RATING | COMMENTS |
|---|---|---|---|---|
| Ball (440C) | Liquid or Gas | Fair. Limiting factor - 440C Stainless. | -450°F to 300°F | Greatest reliability. |
| Pivot (Synthetic Jewel Pivot, Carbide Shaft) | Gas or Liquid | Good. Limiting factors - Tungsten Carbide, set screw staking adhesive [2] | Up to 600°F [1] | Best low flow performance. |
| Pivot (Synthetic Jewel Pivot, Jewel Shaft) | Gas or Liquid | Excellent. Limiting factor - Set screw staking adhesive [2] | Up to 600°F [1] | Best low flow performance. |
| Carbide Journal[1] | Liquid | Good. Limiting factor - Tungsten Carbide. | Up to 1200°F [1] | Excellent wear resistance. |

---

[1] Limiting factor is set screw staking adhesive. Higher temperature adhesives are currently being sought.

[2] Staking adhesives can be tailored to corrosion resistance requirements at lower temperatures. At higher temperatures the staking adhesive becomes more of a performance limiting factor.

[3] Temperature rating limited by pickoff availability.

### 6.2.3 Blade Angle

The blade angle of the capsule rotor defines the range of flow over which the Turbo-Probe is operational. See Table 2 for details.

### 6.2.4 Range Number

Under certain conditions the same blade angle can cover more than one flow range. See Table 2 for details.

**CAUTION**
**Never use the capsule outside the range designated by the model number. Operation at higher flow rates will result in bearing damage. Operation at lower flow rates will produce inaccurate results.**

### 6.2.5 Type Of Fluid

The Liquid or gas designation effects the base model number designation as well as the flow range and the type of bearing used.

### 6.2.6 Calibration

Depending on the type of Turbo-Probe$^R$, one of the calibrations listed in Table 5 is used. Not all calibrations are available for all Turbo-Probes$^R$. Consult Factory.

## TABLE 5
## TURBO-PROBE$^{R}$ CALIBRATION CHART

| CODE | DESCRIPTION |
|---|---|
| KA | 3 point, K-factor average in Air @ 60°F, 1 atmosphere |
| KW | 3 point, K-factor average in water |
| KS | 3 point, K-factor average in solvent |
| KB | 3 point, K-factor average in oil blend |
| | |
| NA | 10 point, normal 10:1 range, in air |
| NW | 10 point, normal 10:1 range, in water |
| NS | 10 point, normal 10:1 range, in solvent |
| NB | 10 point, normal 10:1 range, in oil blend |
| | |
| XA | 10 point, extended range, in air |
| XW | 10 point, extended range, in water |
| XS | 10 point, extended range, in solvent |
| XB | 10 point, extended range, in oil blend |
| | |
| TA | 20 point, normal 10:1 range, in air |
| TW | 20 point, normal 10:1 range, in water |
| TS | 20 point, normal 10:1 range, in solvent |
| TB | 20 point, normal 10:1 range, in oil blend |
| | |
| YA | 20 point, extended range, in air |
| YW | 20 point, extended range, in water |
| YS | 20 point, extended range, in solvent |
| YB | 20 point, extended range, in oil blend |
| | |
| FA | 15 point, extended range, in air |
| FW | 15 point, extended range, in water |
| FS | 15 point, extended range, in solvent |
| FB | 15 point, extended range, in oil blend |
| | |
| GA | 30 point, extended range, in air |
| GW | 30 point, extended range, in water |
| GS | 30 point, extended range, in solvent |
| GB | 30 point, extended range, in oil blend |

### CODES FOR REYNOLDS NUMBER ONLY

| | |
|---|---|
| R1 | 10 point, normal 10:1 range, density gas, 1 pressure |
| R2 | 10 point, normal 10:1 range, density gas, 2 pressure |
| R3 | 10 point, normal 10:1 range, density gas, 3 pressure |

| | |
|---|---|
| E1 | 20 point, normal 10:1 range, density gas, 1 pressure |
| E2 | 20 point, normal 10:1 range, density gas, 2 pressure |
| E3 | 20 point, normal 10:1 range, density gas, 3 pressure |

### 6.3 ELECTRONICS

A variety of electronic packages are available from FTI FLOW TECHNOLOGY that will process the output generated by the pickoffs into signals like 10V peak pulse, or analog signals such as 0 to 5V, 0 to 10V, 1 to 5V, 4 to 20mA, or 4 to 20mA loop powered. Consult factory for available configurations.

## 7.0 MAINTENANCE

### 7.1 ROUTINE MAINTENANCE

Maintenance of the Turbo-Probe$^{R}$ consists of periodic inspection to insure that the internal parts have not been fouled or suffered any corrosion. Should the assembly be damaged in any way, it should be returned to the factory for exchange or repair.

Turbine type flowmeters are precision devices and must be treated as such. The freedom with which the rotor is allowed to rotate is the major contributor to this precision.

The majority of fluids measured by probes contain impurities, which if allowed to remain, after use, would form hard or gummy residues. When these residues are deposited within the probe, the unit's freedom of rotation will be severely degraded.

Therefore, it is highly recommended that whenever possible the Turbo-Probe$^{R}$ should be THOROUGHLY FLUSHED with an appropriate solvent immediately after use. The solvent should be chemically neutral, and HIGHLY VOLATILE so that COMPLETE DRYING can take place soon after the flushing operation. Some appropriate solvents would be ethyl alcohol, freon, stoddard solvent, or trichloroethane.

**CAUTION**
**DO NOT OVERSPEED BEARINGS**
**Care must be taken when flushing the Turbo-Probe,**
**not to overspeed or otherwise damage the bearings**
**and rotor assembly.**

A zerk fitting is provided just above the flange in order to increase the life of the thrust ball bearing. This is for the retractable portion of the probe only, and has no effect on the probe assembly. It is isolated from the service line and its purpose is to help maintain smooth operation of the retractable portion. The fitting should be greased periodically.

Sta-Lube boat trailer wheel bearing grease is applied at the factory. This product or a similar product that passed the American Society of Testing Material Standard No. D1743 is recommended.

## 7.2 REPAIRS

Repairs for the Turbo-Probe$^R$ are generally limited to replacing or rebuilding the rotor capsule assembly, and the replacement of the strut seal, when applicable. The procedure for accomplishing the repairs are described in the following paragraph. When ordering parts, it is necessary to provide the complete model number and serial number of the
Turbo-Probe$^R$.

### 7.2.1 Replacement of Rotor Capsules for Turbo-Probe7

Replacing the entire capsule of a Turbo-Probe$^R$ is a simple operation. After the probe has been detached from the line, refer to Section 5.0 Installation, follow the steps listed below:

a) Remove two retaining screws from the capsule housing.

b) Press capsule out of housing.

c) Insert replacement capsule, insuring that the flow direction arrow on the capsule matches the arrow on the housing and/or strut. If the new capsule contains pivot bearing, refer to Section 5.2 Mechanical Installation.

e) Re-install the 4-40 retaining screws.

#### 7.2.1.1 Calibration Data

When a Journal bearing rotor capsule or Pivot bearing rotor capsule is replaced, the replacement is calibrated at the factory before shipment and new calibration data issued. This new calibration data should be used.

When the ball bearings are replaced in a ball bearing rotor capsule used in a gas application, there may be a slight shift in the K-factor. In liquid applications any shift would be negligible.

### 7.2.1.2 Replacement of Old Style Turbo-Probe$^R$ Capsules.

Several years ago, FTI FLOW TECHNOLOGY was compelled to change the design of the Turbo-Probe$^R$ capsules to the current configuration so that performance enhancements could be achieved. Many of the old capsules are still in service and occasionally need factory service. If it is determined that the capsule is not repairable, and it needs to be replaced, a new style capsule is used as a replacement. The two styles are completely interchangeable with the exception of the method of retaining the capsule within its housing. Refer to Figure 17.

The new design for rotor capsules has a formed stainless steel support of approximately .016 inches thickness which cannot be threaded for the two retaining screws. Therefore, when the older style, capsule with post supports, is replaced with a new style capsule, it is necessary to thread the holes through the capsule housing (the head of the strut) in order to hold the screws to retain the new supports. A 4-40 thread tap is included with the replacement capsule. Follow these procedures for capsule replacement:

a) Remove two retaining screws from the capsule housing.

b) Press old capsule out of the housing.

c) Using 4-40 thread tap (included with replacement capsule); thread the two screw holes. If the new capsule contains pivot bearings, refer to the Mechanical Installation Section in this manual.

d) Insert replacement capsule, insuring that the flow direction arrow on the capsule matches the arrow on the housing and/or strut.

e) Insert new 4-40 retaining screws.

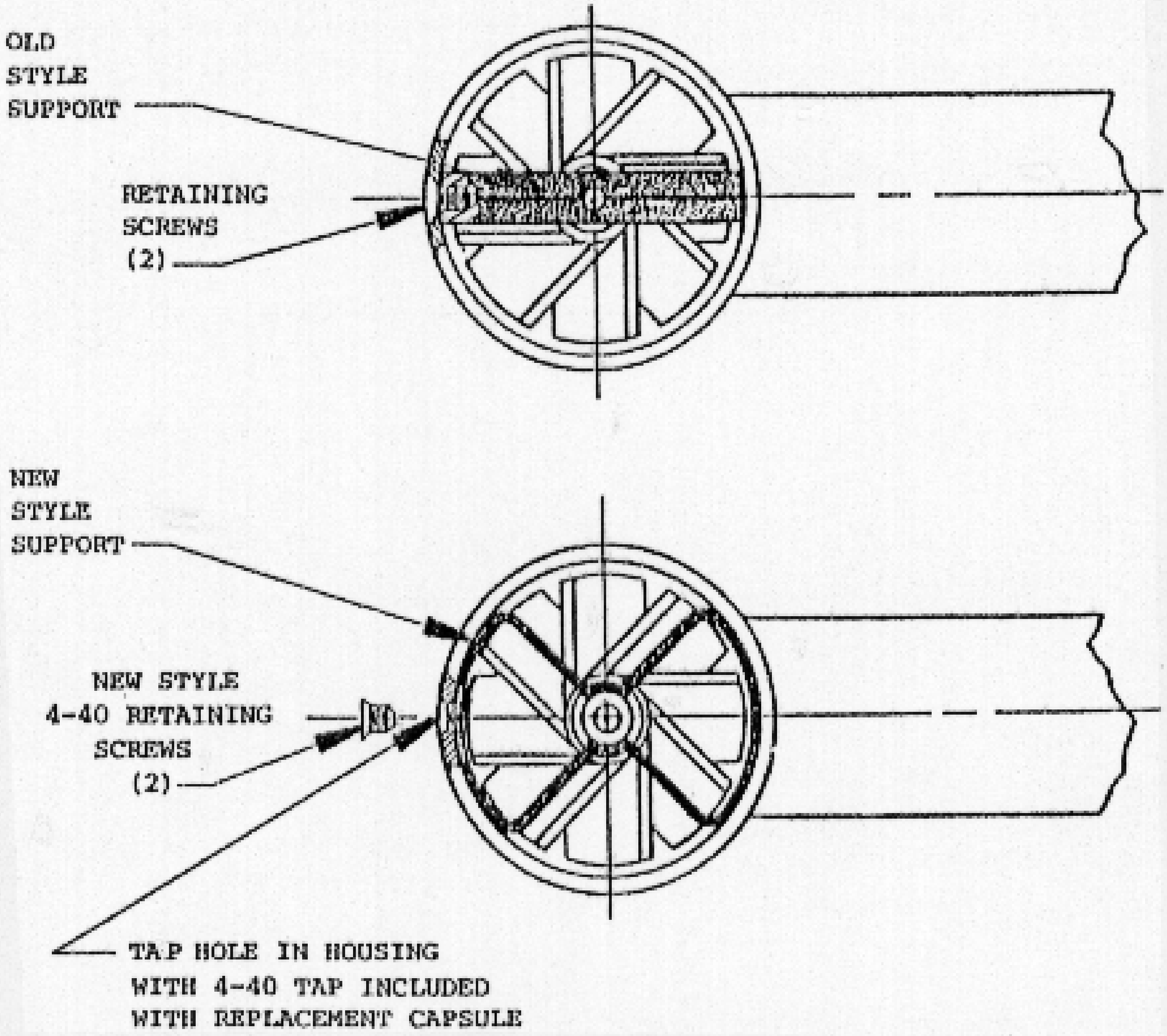


Figure 17. New and Old Style Rotor Capsule for Turbo-Probe$^R$.

### 7.2.2 Rotor Assembly Repair

Refer to Figure 18 for Rotor Assembly Repair/Replacement.

#### 7.2.2.1 Ball Bearing

1. Remove the two retaining screws (2) from the bottom of the capsule housing (1) which holds the rotor supports in place.

2. Gently press supports (3), with rotor and bearings, from the housing (1).

**CAUTION**

**DO NOT PRESS ON ROTOR**

3. Remove the set screw shaft (8) from the support (3). To remove the set screw shaft, it may be necessary to heat the support with a heat gun to loosen the Loctite.

4. Rotor assembly (7) will come free from the support (3).

5. Remove the retaining rings (4) from the rotor assembly which hold the bearings in place, and press the bearings out. Place spacer (6) between bearings.

6. Install the new bearings (5) in the rotor (7) with spacer (6) between them. The ball bearings are symmetrically designed so they may be replaced with either side upstream.

7. Replace the retaining rings (4) to hold the bearings in the rotor.

8. Replace the rotor in the supports and secure the set screw shaft (8).

9. Apply Loctite-242 to set screws.

10. Replace the supports/rotor assembly in capsule housing (1). Insure that the rotor assembly is oriented with the marks on the rotor hub (between the blades) downstream. Replace two retaining screws (2).

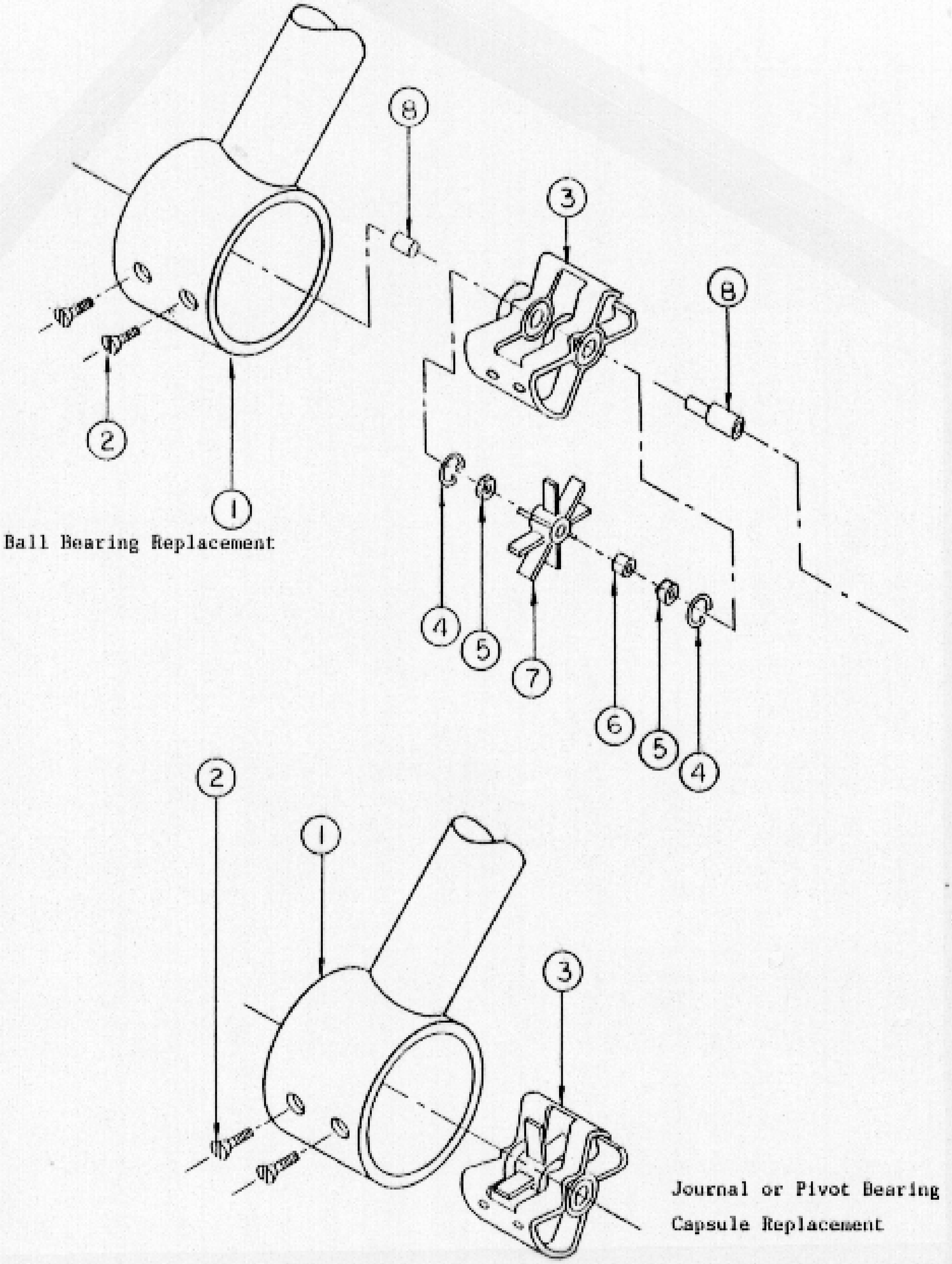
### 7.2.2.2 Pivot and Journal Bearings

A Turbo-Probe$^R$ with Journal or Pivot bearings are limited to the replacement of the complete capsule assembly. When shipping the completed capsule assembly to the factory for repairs, insure that the capsule is shipped in the special capsule container.

1. Remove the two retaining screws (2) from the bottom of the capsule housing (1) which holds the rotor supports in place.

2. Gently press supports (3), with rotor and bearings from the housing (1) reversing the procedures in paragraph 5.2.

To install a spare or replacement pivot or journal capsule, replace supports/rotor assembly in capsule housing (1) and replace two retaining screws (2). Insure that the flow direction arrow on the capsule is oriented in the same direction as the arrow in the capsule housing, more importantly, the same direction as the flow. Follow the assembly instructions in paragraph 5.2.



Ball Bearing Replacement

Journal or Pivot Bearing Capsule Replacement

Figure 18. Rotor Assembly Repair/Replacement

### 7.2.3 Seal Replacement

When there is evidence of excessive leaking, the seal around the probe, located in the flange, should be replaced.

#### 7.2.3.1 Seal Replacement for T8 and T9

Use the following procedures and refer to Figure 18 for seal replacement:

A) Completely retract the probe into the flange by turning the wheel counter-clockwise.

B) Close the isolation valve, if applicable, or shut down the flow line.

C) Disconnect electrical connections (condulet). Remove the Turbo-Probe$^R$ from the flow line.

D) Place the Turbo-Probe$^R$ in a vertical position on a piece of clean cardboard or plywood.

E) Loosen the two allen-head set screws (47-85889) and remove the hand wheel (62-85214).

F) Loosen bolts securing the counter and remove the drive belt (19-90839), if applicable.

G) Loosen set screw and remove counter drive pulley (59-85240) from screw shaft (47-85210), if applicable.

H) Remove the two nuts (46-90171) and remove the end cap (37-85206 or 37-85229) and spacers (48-90815) from the probe housing (58-85205 or 58-85233), whichever is applicable.

I) Using a small wire hook, gently pull up on pickoff wires until connector (15-90830) are accessible.

J) Loosen the screw (47-90278) securing the cable tension relief clamp (43-90825).

K) Attach a piece of cord to the coiled cable (19-85237) and secure it to the explosion proof enclosure (condulet) on the outside of the probe housing (58-85205 or 58-85233), whichever is applicable. This is to prevent the cable from becoming entangled or damaged.

L) Remove probe housing (58-85205 or 58-85233), whichever is applicable, by pulling firmly upward while holding the flange. It may be necessary to tap the housing with a rubber mallet at the flange end while pulling upward.

M) Remove two allen-head set screws (47-90808) from the brass block (38-85204 or 38-85232), whichever is applicable, which secures the block to probe.

N) Place Turbo-Probe$^R$ in horizontal position and remove probe from flange by pulling it out toward the bottom.

**NOTE**

**It may be necessary to replace the handwheel and run the block down to extend the probe far enough to grasp it.**

**CAUTION**

**When removing probe and replacing it, care must be taken not to damage wires or connectors. The strut surface must be protected at all times. Scratches or dents will prevent proper sealing.**

O) Remove Spiro-Lok retaining ring (57-13038) and washer (48-17051) from flange.

P) Remove old seal (50-90092 or 50-90827), whichever is applicable.

Q) Install new seal.

**CAUTION**

**New seal must be installed with the lip toward the face of the flange. Care must be taken not to damage the lip when installing the seal or when inserting the probe through the seal.**

R) Replace washer (48-17051) and retaining ring (57-13038).

S) Re-insert probe through the flange (13-85211 or 13-85234), whichever is applicable, and insert a new seal (50-90032 or 50-90827) whichever is applicable, taking care not to damage seal.

T) Insert probe (13-85207 or 13-85230), whichever is applicable into brass block (38-85204 or 38-85232), whichever is applicable carefully feeding wires and connectors through the hole, and aligning holes in probe with holes for allen-head set screws (47-90808).

U) Install allen-head set screws (47-90808) and tighten securely.

**CAUTION**
**DO NOT OVER TIGHTEN**

V) Fully retract probe into flange, and place Turbo-Probe$^R$ back into vertical position on clean surface.

W) Replace probe housing (58-85205 or 58-85233), whichever is applicable, onto the flange assembly (13-85211 or 13-85234), whichever is applicable, aligning the explosion-proof enclosure with the flat side of brass block (38-85204 or 38-85232) whichever is applicable.

X) Reconnect pickoff wire/coiled cable connector.

Y) Replace coiled cable under tension relief clamp (43-90825) and tighten screw (47-90278).

Z) Carefully tuck connectors and excess wire into hole in brass block (47-90808).

AA) Replace the spacers (48-90815) on the screw shaft (47-85210) and replace the housing end cap (37-85206 or 37-85229) whichever is applicable.

BB) Replace the two nuts (46-90171) to secure end cap.

CC) Replace the counter drive pulley (59-85240) on screw shaft (47-85210) and tighten the set screw, if applicable.

DD) "Zero" depth indicator counter by adjusting probe (13-85207 or 13-85230) whichever is applicable, in the flange assembly (13-85211 or 13-85234) whichever is applicable, until the centerline of the rotor shaft is flush with the face of the flange and ensuring that the counter reads zero, then replace counter drive belt (19-90839) and tighten the bolts securing counter.

EE) Replace handwheel (62-85214) aligning set screw (47-85887) with dimples in screw shaft (47-85220) made by previous installing handwheel and tighten set screws firmly - <u>DO NOT</u> <u>over tighten.</u>

FF) Reinstall Turbo-Probe$^R$ in the flow line. (Refer to Section 5.2 Installation).

### 7.2.3.2 Seal Replacement for TB Series

When there is evidence of excessive leaking from the seal around the probe which is located in the flange or NPT housing, the seal should be replaced.

Use the following procedure and refer to Figures 19, 20 and 21 for seal replacement.

**WARNING**

**Do not attempt to loosen the Swagelok$^R$ locking nut on the Turbo-Probe$^R$ while the line is under pressure. Loosening the locking nut will allow the probe to ascend to the limit or the capsule housing or stop assembly which could cause physical damage. Adhere to the warning affixed to the Turbo-Probe$^R$ housing and take precautions against injury.**

A) Completely retract the probe in the flange housing or NPT housing, whichever is applicable.

B) Close the isolation valve, if applicable, and bleed off all trapped pressure from the flow line, if applicable, or shut down the flow line.

C) Disconnect electrical connections. Remove the Turbo-Probe$^R$ from the flow line.

D) Place Turbo-Probe$^R$ in vertical position on a piece of clean cardboard or plywood.

E) Loosen the Swagelok$^R$ fitting and remove the stop assembly (65-85076-101).

F) Remove the handle assembly (42-51438-101) and the explosion proof enclosure (73-31836-102).

G) Pull the strut assembly from the bottom out of the flange housing assembly (13-51230-102) or NPT housing assembly (13-51308-101) whichever is applicable.

H) Remove the retaining ring (57-13038-125) and seal retainer (48-17286-01).

I) Remove old seal (50-90082-214) from housing.

J) Install new seal (50-90082-214).

**CAUTION**

**The new seal must be installed with lip toward face of flange or toward NPT thread whichever is applicable. Care must be taken not to damage lip when installing seal or when inserting strut through seal.**

K) Replace the seal retainer (48-17286-01) and the retaining ring (57-13038-125).

L) Re-insert probe through housing (13-51308-101) or (13-51230-102) whichever is applicable and new seal

(50-90082-214), taking care not to damage seal.

M) Screw handle assembly (42-51438-101) and explosion proof enclosure (73-31836-102) back onto the strut assembly (13-51370).

N) Re-install stop assembly (65-85076-101) and tighten Swagelok$^R$ fitting.

O) Re-install Turbo-Probe$^R$ in the flow line (Refer to Section 5.2 Installation).

### 7.2.3.3 TL Low Profile Turbo-Probe$^R$ Seal Replacement

The seal should be replaced, when there is evidence of excessive leaking from the seal located in the bearing housing. Use the following procedure and refer to Figure 22 for seal replacement.

A. Completely retract the probe (1) into the lower bushing (3).

B. Close the isolation valve (2).

C. Disconnect the electrical connections. Disconnect the pickoff wires inside the electrical enclosure (9,10).

D. Loosen the two allen-head shoulder screws on the electrical connector block (6) and the two allen-head shoulder screws on the bearing/seal housing (4) and then remove the scissor type lever assembly (5).

E. Loosen and remove the two screws on the connector block (6). Remove the connector block from the top of the strut. Be careful not to damage the pickoff wires or the connector block.

F. Loosen the brass bearing/seal housing (4) by turning it counterclockwise. Slide the housing over the strut (1).

G. Remove the retaining ring (11) from the bearing/seal housing (4).

H. Remove the spacer (12) and the old seal (13).

I. Install the new radial seal (13), preferably using an aluminum push rod.

**CAUTION**

**A new seal must be installed with the lip toward the isolation valve (pressure side) and care must be taken not to damage the lip when installing the seal or when inserting the strut through the seal.**

J. Replace the spacer (12) and retaining ring (11).

K. Slide the bearing and seal housing over the strut and fasten the housing by turning it clockwise. Insure the shoulder screw holes are properly aligned so the scissors type lever assembly is perpendicular to the isolation valve stem.

L. Install the electrical connector block.

M. Install the scissor type lever assembly and tighten all the shoulder screws.

N. Connect all the electrical wires.

## 7.3 TROUBLESHOOTING GUIDE

Turbine flowmeters are inherently reliable devices and many of the problems that occur during operation are the result of improper installation and/or maintenance.

In the following pages, a guide shows some of the common problems that occur during the use of turbine flowmeters.

Various causes are given for each problem including a description of the cause and the corrective action to be taken.

### 7.3.1 **Meter Reads High**

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Air in Line - Bubbles or Froth (Liquid Meters Only) | Line not full of fluid. | Check plumbing arrangement. |
| Cavitation (Liquid Meters Only) | Fluid vaporizes as it slips over rotor blades & liquifies beyond blades. | Check for insufficient back pressure. |
| Pulsations (Fluid Surges) | Pump or rotor actions. | Provide damping in system. |
| Viscosity Shift (Calibration Viscosity & Operative Viscosity are Different) | Operating fluid does not have the same viscosity as the fluid used to calibrate the flowmeter.<br>OR<br>Temperature of the metered fluid differs from the temperature used for calibration. | Recalibrate in proper fluid.<br>Recalibrate for the operation temperature. |
| Invalid Calibration | Calibrated in wrong fluid.<br>OR<br>Specifications for calibration not clear | Recalibrate in proper fluid.<br>Clarify specs and recalibrate. |
| Pressure Variations (Gas Meters Only) | Calibrated at atmosphere but run at high density due to high pressure. | Recalibrate at proper density. |
| Distorted Velocity Profile | Flow not conditioned properly. | Relocate probe or install flow conditioners. |

Meter Reads High (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Flow Capsule Misaligned Within Pipe | Capsule not being used under calibrated conditions. | Install probe properly. Insure capsule axis is parallel to pipe axis. |
| Improper Location Of Capsule Within Flow Stream | Capsule not being used under calibrated conditions. | Install probe properly. Refer to Section 8, Theory of Operation. |
| Improper Electrical Installation | Power and signal cables are run together. | Separate cables and check for noise signal of sufficient amplitude to be mistaken as a flowmeter signal. |
| | OR | |
| | Improper hook-up of cable shields. | Check for ground noise that can be mistaken as a flowmeter signal. |
| | OR | |
| | Voltage spikes on signals. | Check for transients and spikes that can be mistaken as a flowmeter signal. |
| | OR | |
| | Gain adjustment of magnetic input amplifier is set high. | Check to see if the input amplifier is amplifying noise signals or is oscillating. |

Meter Reads High (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Improper Mechanical Installation | Gasket intruding into flow stream. | Check to see if the gasket has shifted and is disturbing flow stream. |
| | OR | |
| | RF amplifier is installed in close proximity to the high temperature line. | Locate the RF where the temperature of the fluid line does not affect the operation of RF, possibly an added extension between flowmeter and RF. |
| | OR | |
| | Insufficient filtering. | Check to see if foreign material has built up on rotor or supports. |
| Deformed Flowmeter (Foreign Materials in Flowmeter) | Foreign materials have accumulated on flowmeter internals and act as accelerators. | Check for deposit build-up on orifice. |
| | OR | |
| | Foreign materials in fluid have deformed internals. | Return to factory. |

### 7.3.2 **Meter Reads Low**

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Distorted Signals | Magnetized rotor<br>Hint: Error is some multiple of magnetized blades divided by the number of rotor blades, 10 is the standard #. | Check for unequal signal in repeat pattern. |
| | $NX = \frac{1}{\text{\# of Blades}}$ | Degauss rotor blades. |
| | OR<br>RF Amplifier to flowmeter mismatch | Check for electrical mismatch between RF circuit and the flowmeter. |
| Varying Signal Amplitude | Electronics does not detect some pulses. | Adjust amplifier gain. |
| | OR<br>Bent rotor blades (amplitude and width of signals may vary). | Check to see if the signals produced by the rotor blades are individual pulses. Replace rotor if pulses are not differentiated from each other. |
| Noise Pickup | Power and signal cables are run together | Check to see if large noise signal from motor or relay is preventing the detection of pulses. |
| | OR<br>AC signals override flowmeter signals and are detected as pulses. | Check for 60 Hz signals that attenuate or override flowmeter signals. |

Meter Reads Low (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Distorted Velocity Profile | Flow not conditioned properly. | Relocate probe or install flow conditioners. |
| Flow Capsule Misaligned Within Pipe | Capsule not being used under calibrated conditions. | Install probe properly. Insure capsule axis is parallel to pipe axis. |
| Improper Location Of Capsule Within Flow Stream | Capsule not being used under calibrated conditions. | Install probe properly. Refer to Section 8, Theory of Operation. |
| Weak Flowmeter Signal | Weak flowmeter signal is not detected by electronics. | Check for weak flowmeter signal that may not be detected above the noise level of the electronics. |
| Viscosity Shift | Operating fluid has a viscosity different then the fluid used for calibrating the flowmeter. | Recalibrate in proper fluid. |
|  | OR<br>Temperature change has caused a viscosity shift of the operating fluid. | Recalibrate for the operating temperature. |
| Pulsation (Pump Actions) | Fluid surges (possible, but meter will usually read high). | Provide damping in the system. |

Meter Reads Low (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Improper Electrical Installation | Loose pickoff. | Verify that the pickoff bottoms in the housing and secure locknut. |
| | OR | |
| | Improper hook-up of cable shield. | Check for ground loops that attenuate the signals into the noise level. |
| Improper Mechanical Installation | Fluid contamination | Foreign material in bearings; clean meter internals. |
| | OR | |
| | Meter install backwards. | Check to see if the flow direction arrow on the flowmeter is aligned with the direction of flow. |
| | OR | |
| | Internals installed backwards. | Verify meter is assembled properly. |
| | OR | |
| | Meter installed in different orientation than calibrated. | Check the data sheet to ascertain proper orientation for the flowmeter. |
| | OR | |
| | Filter is installed in the wrong place, or is the wrong size. | Check for deposit build-up on orifice. Clean internals and flush the line. |
| | OR | |
| | Gasket intrudes into line and blocks flow. | Check to see if the gasket has shifted and disturbs the flow of fluid. |

Meter Reads Low (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Calibration in Improper Fluid | Fluid viscosity is not the same as the viscosity of the fluid used for calibration. | Recalibrate in proper fluid. |
| Defective Bearings | Intermittent operation.<br>Frozen or locked. | Clean or flush the system. |
| | OR | |
| | Corroded or worn. | Replace capsule. |
| Pressure Variations (Gas Meters Only) | Calibrated at atmosphere but run at low pressure. | Recalibrate for low pressure. |
| Invalid Calibration (Associated Equipment) | Flowmeter is not mated to proper electronics. | Check data sheets and assemble system correctly. |
| Lack of Lubrication | Bearing misapplication. | Use proper bearing. |

### 7.3.3 Zero Output

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| RF Amplifier | Pickoff not connected or not installed properly. | Check the pickoff. The pickoff must be connected to the readout instrument and be bottomed in the flowmeter housing. |
| | OR | |
| | Impedance mismatch. | Check for compatability between pickoff and readout instrument. Consult Factory. |
| | OR | |
| | High temperature | RF Amplifiers are temperature sensitive and require a high temperature pickoff for high temperature operation. Insure that the fluid temperature is not above the operational temperature range of the pickoff. |
| | OR | |
| | RF Amplifier electronics overheated. | Check that the RF is not placed in proximity of the flowmeter where the fluid temperature can affect the RF operation. |

Zero Output (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Electronic Malfunction | Pickoff is working but the electronic unit does not totalize or perform flow rate indication. | Troubleshoot the electronics. |
| Pickoff Defective or Improperly Installed | Open coil. | Perform resistance check on pickoff leads for 3 to 3000 ohms. |
| | OR | |
| | Broken leads. | Perform resistance check on pickoff leads for above readings. |
| | OR | |
| | Pickoff not bottomed in flowmeter housing. | Finger tighten the pickoff in the flowmeter housing and secure with locking nut. |

Zero Output (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Improper Wiring | Flowmeter and readout instrument are not connected. | Check the wiring to see that the system is interconnected. |
| | OR | |
| | Flowmeter and readout instrument are improperly connected. | Check the wiring to ensure that system is wired correctly between components. Check for connections to wrong terminals, units improperly grounded and loose connections. |
| | OR | |
| | Excessive distance from flowmeter to readout instrument. | Check the distance between components of the system. The maximum allowable distance between the pickoff and the amplifier is 1000 feet for magnetic amplifier and 100 feet for the RF amplifier. |
| | OR | |
| | Broken wires. | Check for signals at both ends of the interconnecting wire. |
| Locked Rotor | The rotor is locked in one position and will not turn. | Flush internals. |
| Defective Bearings | The bearings have worn or corroded and will not permit the rotor to turn. | Replace capsule. |

Zero Output (continued)

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Warped Shaft | Bearing will not rotate on shaft. Internal components are bent, broken or corroded. | Replace capsule. |
| Low Flow | Some readout units contain a low flow cutoff (usually set for 5 or 25 Hz and the unit will not provide an output for flow below the cutoff setting. | Check the flowmeter data sheet for a low cutoff frequency. |
| No Flow | Some of the line valves may be closed so fluid does not pass through the flowmeter. | Check for closed valves. |
| Lack of Lubrication | Journal bearing parts bound together. | Use proper bearing. Consult factory. |

### 7.3.4 **Intermittent Operation**

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Loose Electrical Connections | Connections have worked loose by vibration. | Tighten connections. |
| Improperly Installed Pickoff | Pickoff may become loose in housing. | Tighten pickoff. |
| Noise Pickup | Flowmeter signals are not being differentiated from noise. | Increase gain of preamplifier.<br>Verify that shielding is properly grounded. |
| Electronic Malfunction | Flowmeter is working correctly but electronics are operating erratically. | Troubleshoot electronics. |
| Non-ferrous Rotor Materials | Drift in electronics. | Adjust and align electronics. |
| High Temperature Pickoff | Fluid temperature exceeds range of pickoff. | Replace with proper pickoff. |
| High Temperature Electronics | Electronics are heat sensitive. | Relocate the electronics to reduce temperature to an acceptable level. |
| Bearings | Bearings are worn, broken, corroded, or contaminated. | Replace capsule. |
| Uneven Flow | Flow surging or pulsating. | Increase system back pressure or provide damping. |

### 7.3.5 **Non-Repeatable Meter**

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| Bearings | Bearings are worn, broken, corroded, or contaminated. | Flush internals or replace capsule. |
| Cavitation (Liquid Meters Only) | A portion of the fluid vaporizes as it passes through the meter and again liquifies downstream. | Increase back pressure. |
| Loose Electrical Connections | Connections have worked loose by vibration. | Tighten connections. |
| Improperly Installed Pickoff | Pickoff may become loose in housing. | Tighten pickoff. |
| Noise Pickup | Flowmeter signals are not being differentiated from noise. | Increase gain of preamplifier. Verify that shielding is properly grounded. |
| Electronic Malfunction | Flowmeter is working correctly but electronics are operating erratically. | Troubleshoot electronics. |
| Distorted Velocity Profile | Flow not conditioned properly. | Relocate probe or install flow conditioners. |
| Flow Capsule Misaligned Within Pipe | Capsule not being used under calibrated conditions. | Install probe properly. Insure capsule axis is parallel to pipe axis. |
| Improper Location Of Capsule Within Flow Stream | Capsule not being used under calibrated conditions. | Install probe properly. Refer to Section 8, Theory of Operation. |

### 7.3.6 Constant Meter Output

| PROBABLE CAUSE | OPERATING CONDITIONS | CORRECTIVE ACTION |
|---|---|---|
| RF Amplifier to meter mismatch. | Pickoff and preamplifier mismatch provides constant non-zero output due to oscillation of RF circuit. | Check data sheet. Secure proper components. |
| Improper Switch Position | Run/Calibrate switch on the electronics is in the calibrate position. | Set switch to the run position. |
| Noise | System is detecting a 60 Hz AC signal. | Check system shielding, ground, and gain adjustment. |

## 7.4 SPARE PARTS LIST

### 7.4.1 Capsule Assemblies (See Figure 18)

| ITEM # | PART NUMBER | QUANTITY | NOMENCLATURE |
|---|---|---|---|
| | | BALL BEARING ROTORS | |
| 3 | 91-84090 | 1 | Capsule Assembly |
| 5 | 51-10789-01 | 2 | Bearings, Ball |
| 6 | 41-10060-02 | 1 | Spacer, Ball Bearing |
| 4 | 57-10058-01 | 2 | Retainer, Ball Bearing |
| 2 | 47-90751-03 | 2 | Screw, Capsule Retaining |
| | | JOURNAL BEARING ROTORS (CBD) | |
| 3 | 91-84645 | 1 | Capsule Assembly |
| 2 | 47-90751-03 | 2 | Screw, Capsule Retaining |
| | | PIVOT BEARING ROTORS (JEWEL) | |
| 3 | 91-85039 | 1 | Capsule Assembly |
| 2 | 47-90751-03 | 2 | Screw, Capsule Retaining |
| | | JEWEL BEARING ROTORS | |
| 3 | 91-87648 | 1 | Capsule Assembly |
| 2 | 47-90751-03 | 2 | Screw, Capsule Retaining |

### 7.4.2 Seal Assemblies

T8
See Figure 19

| PART NUMBER | QUANTITY<br>1-INCH STRUT | NOMENCLATURE |
|---|---|---|
| 50-90082-214 | 1 | Seal, Probe Strut |
| 48-17051-02 | 2 | Washer, Strut Seal |
| 57-13038-125 | 2 | Retainer, Strut Seal |

T9
See Figure 19

1 1/2 INCH STRUT

| | | |
|---|---|---|
| 50-90827-01 | 1 | Seal, Probe Strut |
| 48-17051-01 | 2 | Washer, Strut Seal |
| 57-13040-175 | 2 | Retainer, Strut Seal |

TS
See Figures 20 and 21

| | | |
|---|---|---|
| 50-90082-214 | 1 | Seal, Probe Strut |
| 40-17286-01 | 1 | Washer, Strut Seal |
| 57-13038-125 | 1 | Retainer, Strut Seal |

TLXXXXXX
See Figure 22

Spare Parts for the TL Low Profile Probe are Items 11, 12, and 13 on Figure 22.

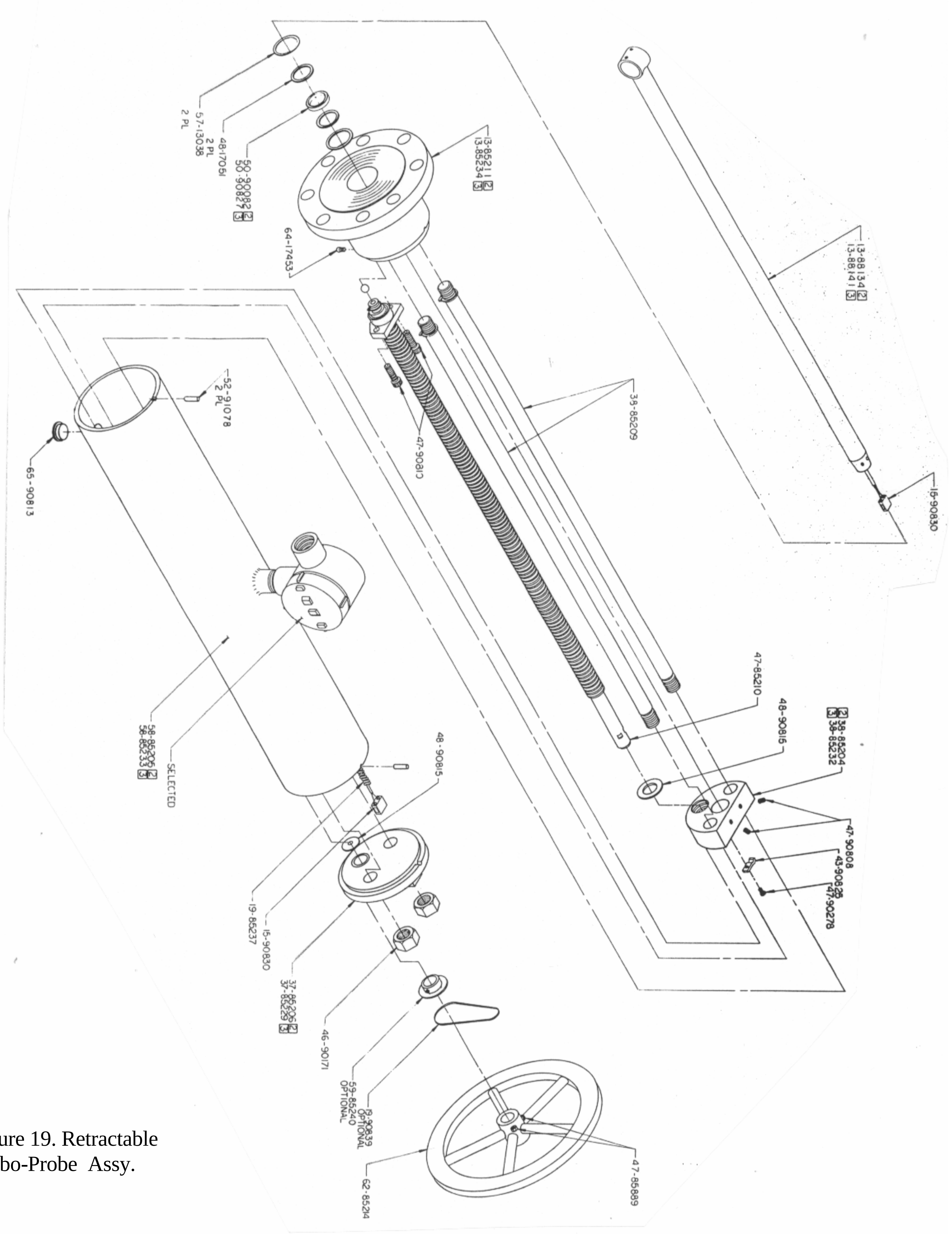


Figure 19. Retractable
Turbo-Probe Assy.

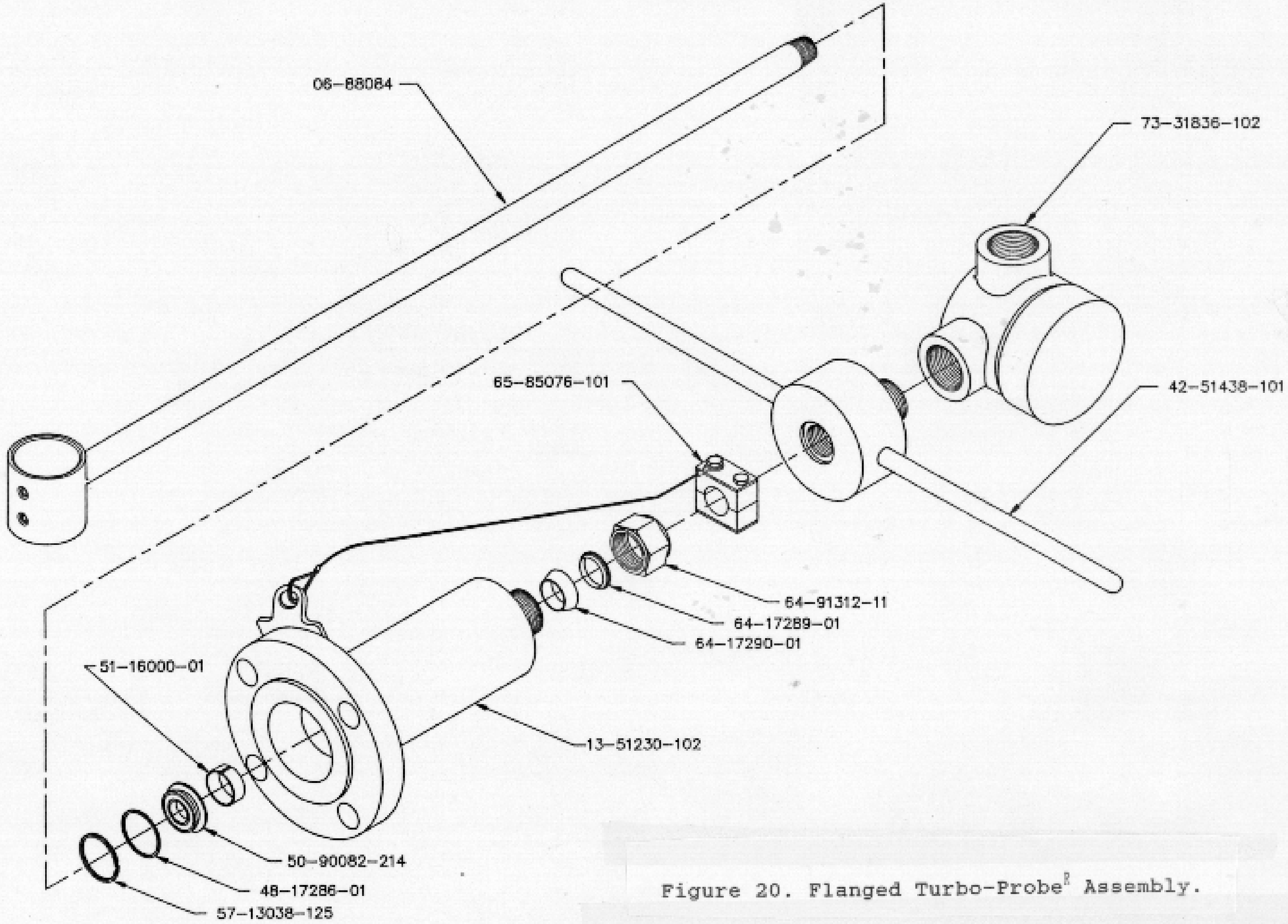


Figure 20. Flanged Turbo-Probe$^{R}$ Assembly.

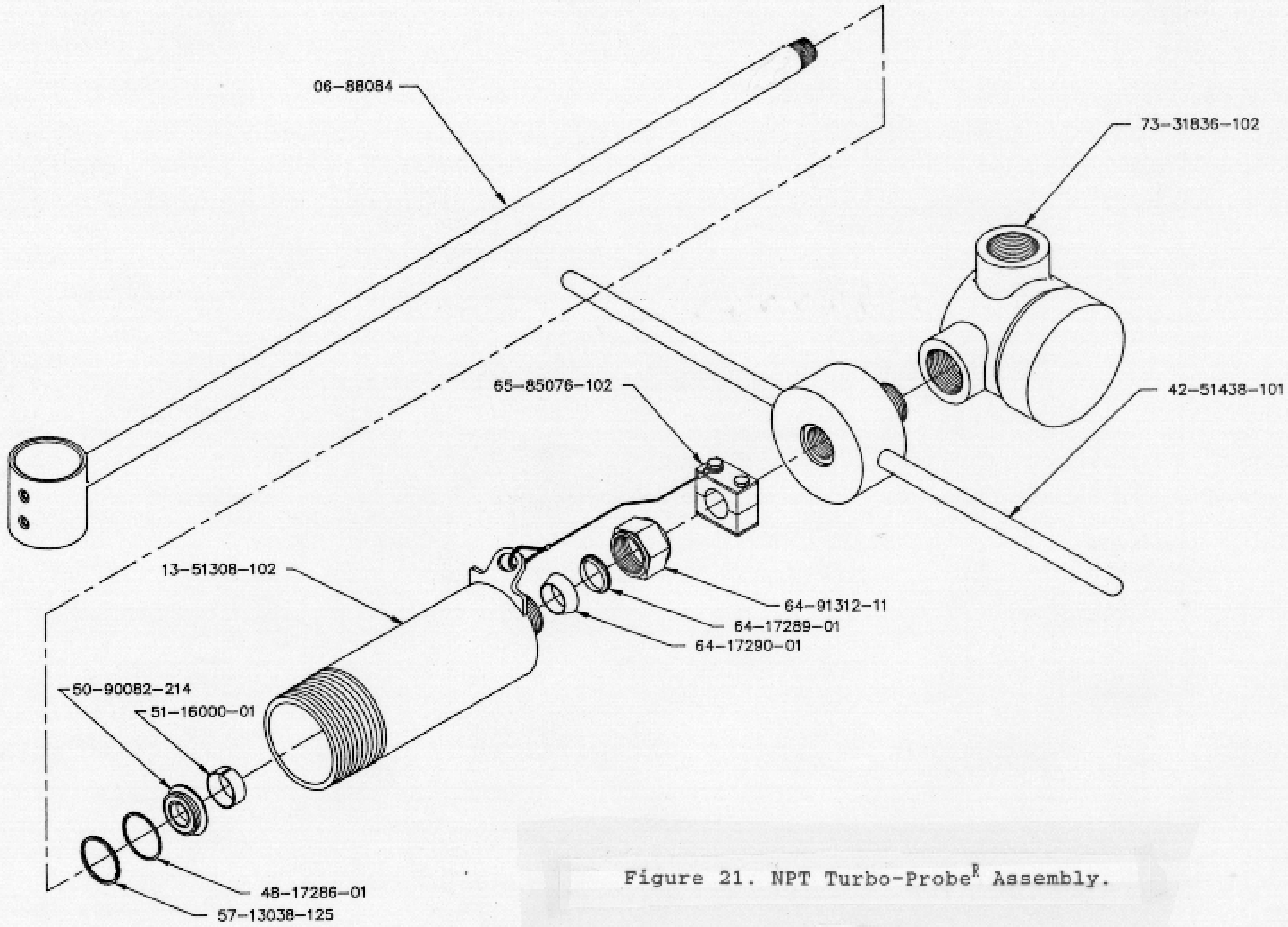


Figure 21. NPT Turbo-Probe® Assembly.

| ITEM | DESCRIPTION |
|---|---|
| 1 | CAPSULE ASSEMBLY |
| 2 | BODY & PICKOFF ASSEMBLY |
| 3 | ISOLATION VALVE ASSEMBLY |
| 4 | BEARING/SEAL ASSEMBLY |
| 5 | ACTUATOR ASSEMBLY |
| 6 | ELECTRICAL CONNECTION BLOCK |
| 7 | REGULATING VALVE |
| 8 | PRESSURE TRANSDUCER (OPTIONAL) |
| 9 | DEPTH INDICATOR |
| 10 | ELECTRICAL ENCLOSURE (OPTIONAL) |
| 11 | RETAINING RING (P/N 57-13038-100) |
| 12 | SPACER (P/N 41-86288-01) |
| 13 | RADIAL SEAL (P/N 50-91227-09) |
| 14 | REMOTE TEMPERATURE DEVICE (OPTIONAL) |

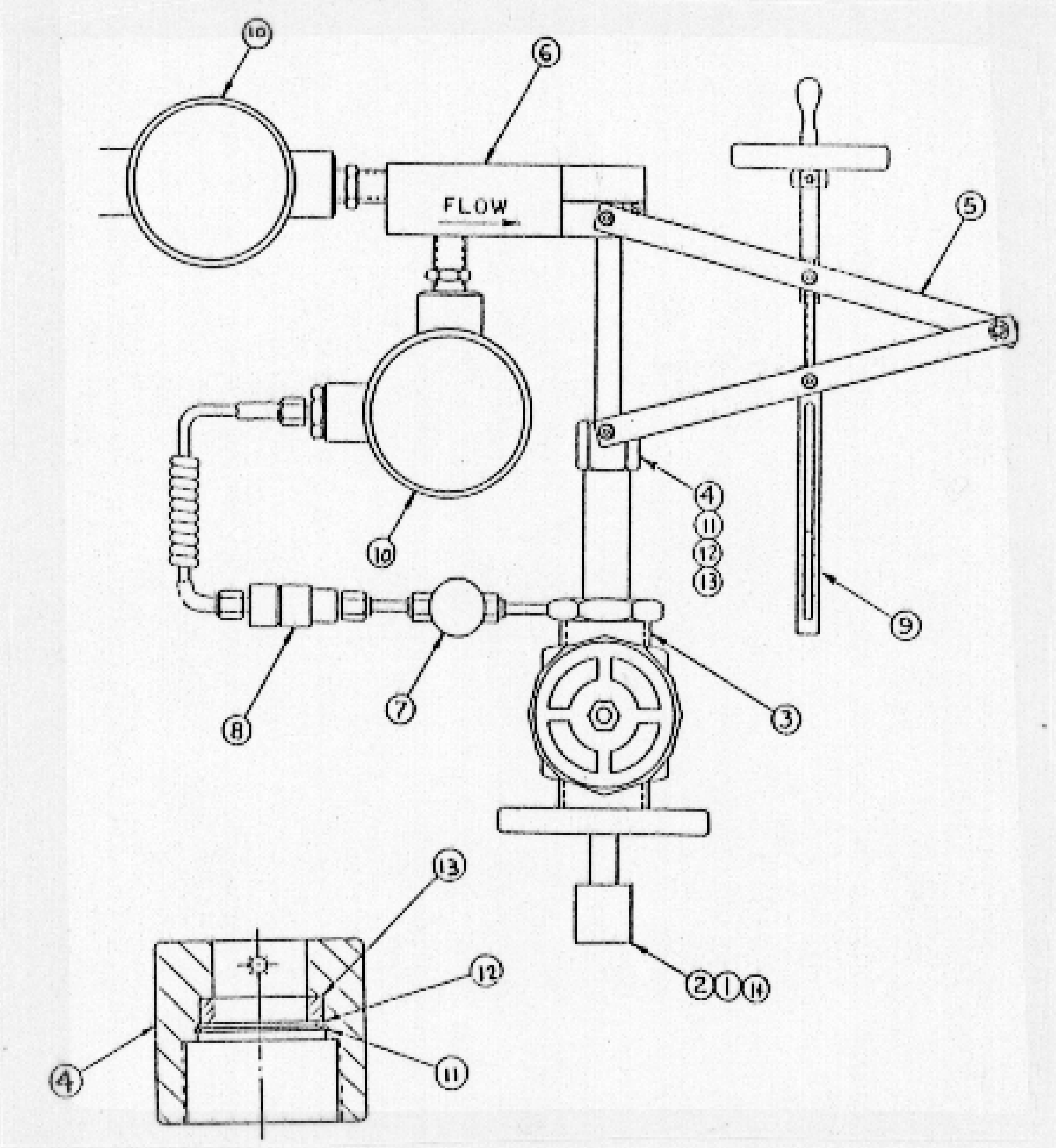


Figure 22. TL Low Profile Turbo-Probe[5] Assembly.

## 8.0 THEORY OF OPERATION

Volumetric flow through a pipe is defined by the following formula:

$$Q = V_mA$$

Where Q is the total flow through the pipe, $V_m$ is the mean velocity of the flow and A is the cross sectional area of the pipe. When the inside diameter of the pipe is known, the area can be calculated. Therefore, if the mean velocity is known, the flow can be calculated.

The insertion turbine flowmeter is a velocity measuring device. Since the flow area is a constant, if the mean velocity point can be measured, then volumetric flow can be inferred.

## 8.1 FLOW PROFILES

Figure 23 illustrates how the velocity profile in the pipe will vary with a change in Reynolds Number (Re). A Reynolds number of less than 2000 represents laminar flow. When the Reynolds Number is above 3000, the flow is turbulent.

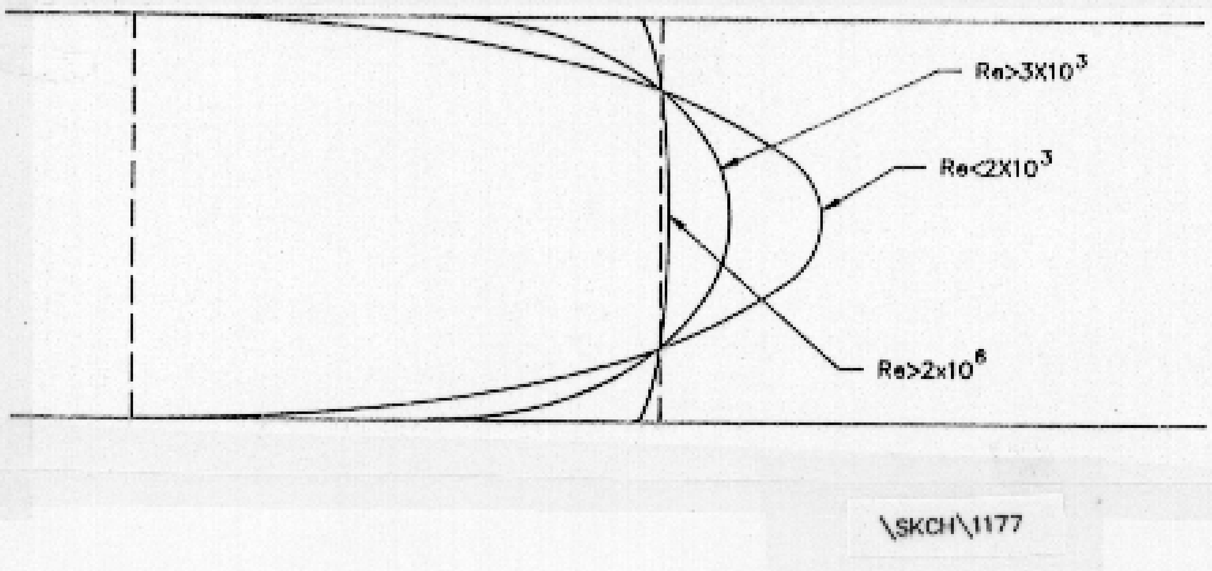


Figure 23. Velocity Profile.

The Reynolds Number is determined by the following formula:

$$Re = \frac{V_m * D}{u}$$

Re = Reynolds Number
$V_m$ = Mean Velocity
D = Pipe Diameter
u = Kinematic Viscosity of Fluid

For a given pipe size and a given flow media, the variable affecting Re is the mean velocity. Re will increase with $V_m$ (flow rate) and the flow profile will change with flow approximately as shown in Figure 23.

## 8.2 LOCATION OF POINT OF MEAN VELOCITY ($V_m$)

Through years of field experience, we are able to determine the location of $V_m$ for normal flow conditions for a wide variety of line sizes. This data collected from actual line profiling correlates very well with the $V_m$ location which can be calculated, using Nikuradse's equations for velocity distribution.

The following is Nikuradse's equation for velocity distribution in a pipe.

$$V_y/V_c = (Y/R)^{1/n}$$

$V_y$ = velocity at position Y in pipe
$V_c$ = velocity at center of pipe
Y = distance from pipe wall
R = pipe radius
n = exponent dependent on Reynolds Number (Re)

Nikuradse's equation for defining the ratio of mean velocity ($V_m$) to centerline velocity is given below.

$$V_m/V_c = 2n^2/[(n+1)*(2n+1)]$$

In order to determine the location of the mean velocity, the two equations are combined as follows:

$$(Y/R)^{1/n} = 2n^2/[(n+1)*(2n+1)]$$

$$Y/R = [2n^2/((n+1)*(2n+1))]^n$$

Y/R is calculated below over a wide range of Reynolds numbers.

Re = 5000 n = 5 Y/R = 0.249

Re = 3 x $10^6$ n = 10 Y/R = 0.237

As can be seen, the point of mean velocity is located at a distance of approximately (1/4) x (pipe radius) or 12% of pipe ID from the inside of the pipe wall regardless of the magnitude of the Reynolds number. This statement holds true within the entire usable range of the probe. Therefore, the local velocity at a point located at a distance equal to 12% of the pipe inside diameter (See Figure 24) will be equal to the average velocity inside the line. If the turbine measuring element is located at this same point, the local velocity read will be equal to the average velocity, and volumetric flow can be inferred simply by multiplying this reading by the area of the pipe.

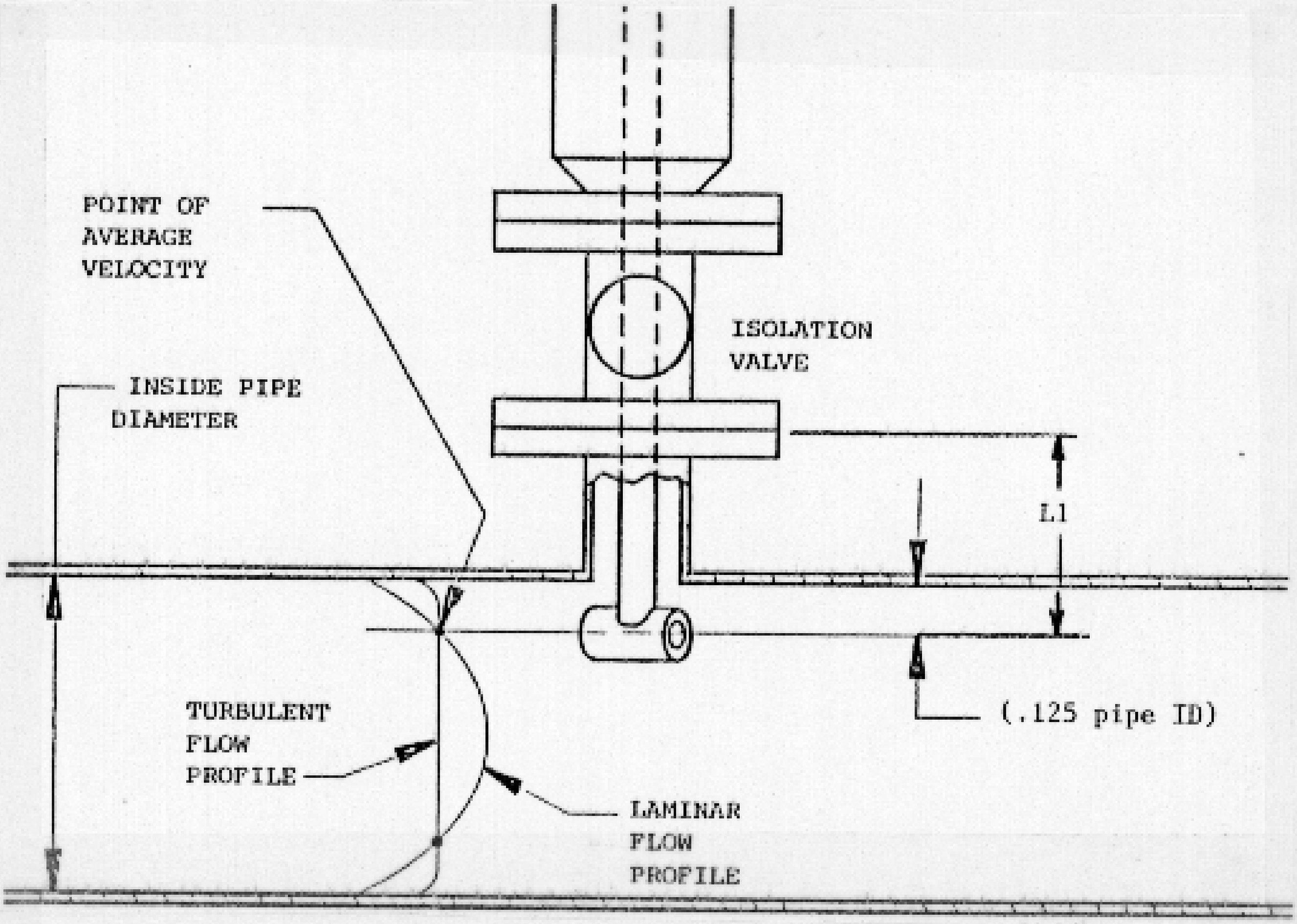


Figure 24. Position of Turbo-Probe® in Flow Channel.

## 8.3 PROFILING AS A MEANS OF DETERMINING THE MEAN VELOCITY POINT

Perhaps the most accurate approach in determining the mean velocity is to measure the velocity at multiple points across the flow stream and calculate the volumetric flow rate based on the multiple measurements.

The average velocity in the line is not equal to the arithmetic average of the velocities measured. This is because points near the center represent smaller areas than do points near the wall of the pipe. The readings can be averaged arithmetically, however, if they are taken at preselected points which represent equal annular areas. The location of points representing equal areas are illustrated in Figure 25 below. The average of 10 velocities measured at the point shown below will be an excellent approximation to the average velocity. Profiling is required when the flow is not fully developed such as in cases where elbows or valves are installed just upstream of the metering point.

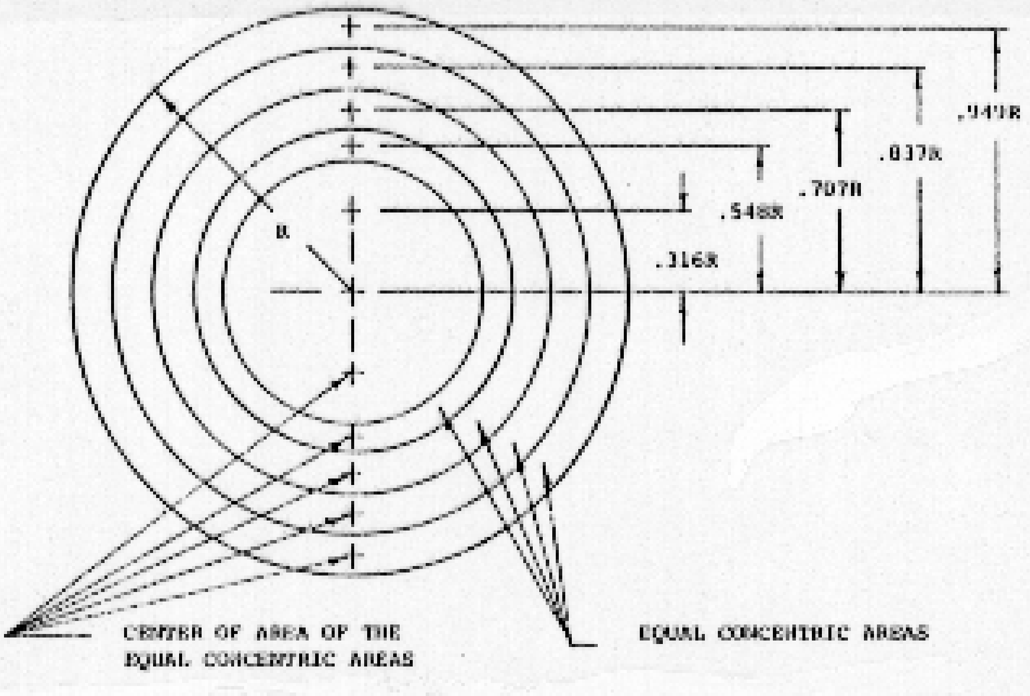


Figure 25. Concentric Area Diagram.

## 8.4 OBSTRUCTION DUE TO PRESENCE OF PROBE

When the insertion turbine meter is inserted into the line, it presents a small obstruction to the flow and reduces the cross sectional area of the pipe. As a result of this obstruction, the velocity of media increases as it passes the probe and the meter reads a velocity slightly higher than the true flow velocity. This effect can be neglected if the probe has been calibrated under conditions of use.

Normally, during calibration the velocity at the turbine is defined for specific output frequencies. Since the probe obscures a portion of the flow area, a correction factor may be required. For large diameter pipes (above 18 inch diameter) this correction becomes negligible.

The true flow velocity is given by the following equation:

$$V_t = [(A - A_o)/A]*V_i$$

Where: $V_t$ = true velocity upstream from probe location
$V_i$ = indicated velocity at probe location
$A$ = cross sectional area of pipe
$A_o$ = flow area obstructed by the probe (turbine and strut)
$V_i$ = indicated velocity at probe location (FT/min)
$A$ = cross sectional area of pipe (in$^2$)
$A_o$ = flow area obstructed by the Turbo-Probe$^R$ (in$^2$)
$(A_0)_I = (0.21 + 1.00 \text{ x } L_1)$ in$^2$ for 1 inch strut and "formed" rotor support
$(A_0)_{II} = (0.35 + 1.00 \text{ x } L_1)$ in$^2$ for 1 inch strut and "post" rotor support
$(A_0)_{III} = (0.21 + 1.50 \text{ x } L_1)$ in$^2$ for 1-1/2 inch strut and "formed" rotor support
$(A_0)_{IV} = (0.35 + 1.50 \text{ x } L_1)$ in$^2$ for 1-1/2 inch strut and "post" rotor support

Where: $L_1$ is the distance in inches from the inside wall of the pipe to the axis of the rotor in the flow stream. (Refer to Figure 24.)

For applications in pipes of less than 6 inches in diameter it is required to position the turbine sensing element at the center of the pipe so that the pipe wall effects do not interfere with the accuracy of the instrument. Under turbulent flow conditions, the velocity profile is flat (constant velocity throughout the pipe cross section) and the velocity at the center of the pipe is close to the value of the mean velocity. When the flow pattern is not turbulent, proper positioning of the probe requires complex calculations beyond the scope of this paper. In this case it is preferable that the probe is calibrated under actual conditions of use or that a full bore flowmeter is used.

## 8.5 CALIBRATION

Two methods of calibration, velocity and volumetric, are available. Using the velocity method, the probe is calibrated so that its frequency corresponds to actual velocity. The user is then responsible to apply corrections for the irregularities of the velocity profile and obstructions inside the pipe due to the probe itself, as described in the previous paragraphs.

For applications where the installation of the probe can be defined in advance, the volumetric calibration method can offer significant advantages. Using this method, the probe is calibrated under conditions closely resembling those of actual usage. The line size and the location of the probe within the line as well as the method of installation during calibration must be kept the same as in the actual conditions of use. The frequency of the probe can then be correlated to actual volumetric flow. This method eliminates the errors due to the various corrections and results in more accurate flow rate measurements. It does however, reduce the versatility of the insertion turbine meter as a flow measuring instrument since this meter now must be dedicated to a specific application.