

NIAGARA[®]

Nutating Disc Meter

**Installation, Operation
and Maintenance Manual**

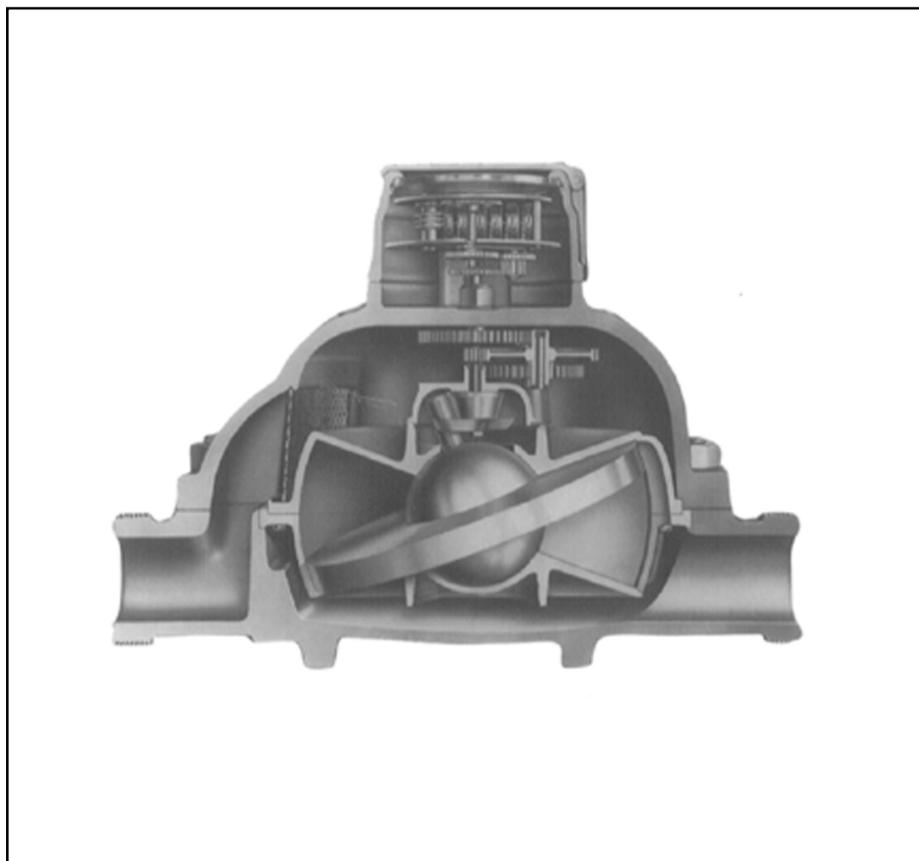


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Installation

LAYOUT OF PIPING

It is necessary to install the meter correctly if an accurate measurement is to be obtained. Note *Diagrams A, B, and C* for correct installation, and the following principles of installation:

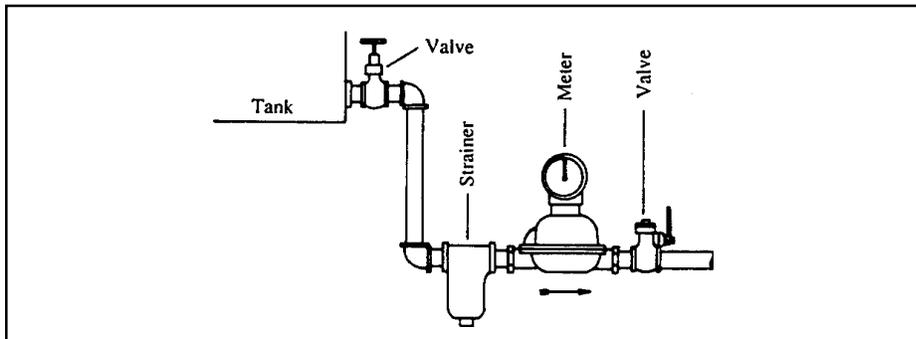
Set the meter in a horizontal pipe with the register up. The meter must remain flooded at all times. To help keep air out, do not let the meter drain between periods of usage. Trap the meter in a depression in the pipeline if necessary. Keep suction lines and pump stuffing boxes tight. If air cannot be kept out of a line handling light oils or solvents, use an air release valve between the pump and the meter.

When needed, protect the meter from sediment, pipe scale, etc. by a trap strainer. Arrange installation so that the strainer can be easily cleaned.

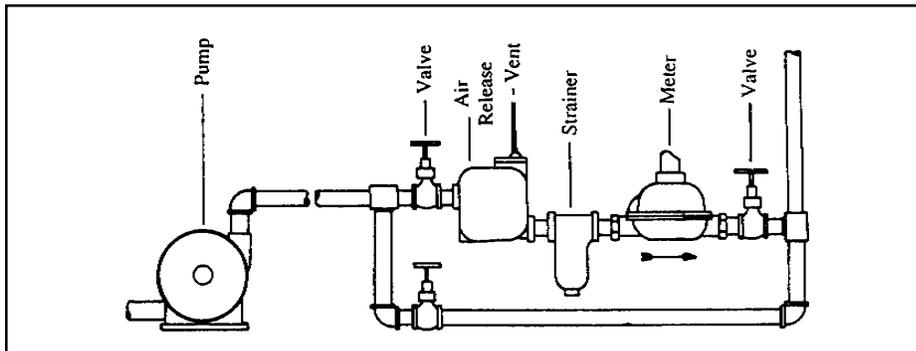
In gravity-pressure installation, set the meter to take advantage of all possible pressure head. In pump-pressure installations, set the meter on the discharge side of the pump.

Use the meter only with the liquid for which it was ordered and within the specified limits of pressure, temperature, and flow rate.

If the line must be kept in continuous service, install a bypass around the meter and strainer with valves.



A. Gravity flow from storage tank with tank valve, strainer, meter, and control valve respectively. If there are many elbows or if very fast flow is wanted, the net drop should be at least two feet more.



B. Pump pressure flow from the storage tank with pump, air release valve, strainer, meter, control valve, and riser pipe respectively. The air release may be omitted if the supply tank will never be emptied. If the supply tank is below the pump level, valves on the suction line must be tight. If the delivery tank is below meter level, a one foot rise pipe on the meter outlet should be used with a vacuum breaker or vent at the high point.

Before placing the meter in the pipeline and after the meter couplings are connected into place, flush the line thoroughly with liquid to remove pipe cuttings, chips, etc. Then set the meter in position. *When starting up the meter, slightly open the control valve to fill the line and the meter with liquid very slowly. Some meter internals may be damaged if run rapidly before the line is full.*

Typical installation are shown to illustrate principles involved. (For installation of auxiliary equipment with electriccontact meters, see the *Electriccontact Sheet* shipped with that meter.)

OBTAINING ACCURATE MEASUREMENT

Avoid passing air or vapor through the meter. Air registers like liquid and produces inaccurate measurement. Use an air release valve to accomplish this if necessary. Do not let the pump run after the supply tank is empty. Sometimes small leaks on the suction line of the pump will cause air to be sucked into the pipe line causing inaccurate registration of the meter. These cannot usually be detected by any leakage of oil; therefore, care must be taken to keep the pipe absolutely tight, especially on suction lines.

KEEPING THE METER CLEAN

If the meter registers much more than the liquid that actually passes through it, in most cases this is due to air passing through the meter with the liquid. The only remedy is to keep the air out. If the meter stops or registers much less than what actually passes through it, this is due to dirt (or sometimes to wear). The meter should be cleaned or repaired as described in *Emergency Cleaning and Inspection*.

Each meter is individually calibrated before being shipped from the factory.

EMERGENCY CLEANING OR INSPECTION

Unbolt the main flange and lift off the entire top half of the casing. Lift out the measuring chamber in which the nutating disc moves. Separate the two halves, removing any screws which hold the two halves together. Lift out the measuring disc and inspect this carefully for dirt embedded in the metal. Clean off any embedded dirt with fine emery paper, but do not attempt to cut away any metal.

Clean out any dirt and place the disc back in the chamber.

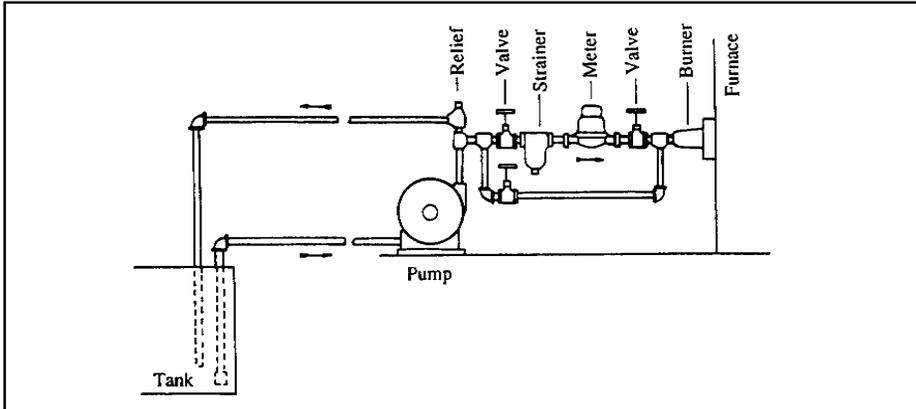
Replace the measuring chamber and disc into the bottom casing of the meter. Replace the flange gasket or use a new one obtained from the factory. Then carefully set the top casing to avoid damage to the internal gears. After reassembly, the meter should operate when held to the mouth and air blown through it.

Clean the strainer ahead of the meter occasionally to prevent clogging and allow full flow through the meter.

SPEED OF OPERATION

A meter must be operated within its proper capacity range. Niagara meters can be operated up to their full rated capacity without damage. However, continuous operation above 50% of maximum flow capacity should be avoided to prevent reduction in normal service life. For details, see the *Niagara Selection Guide*.

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C. Installation on pump pressure oil burners have circulation system. Meter should be kept outside the circulation loop if possible. If two meters must be used on supply and return lines, first pump oil through the system with the burner shut off to check the exact uniformity of registration of the two meters. Be sure that the valve on the suction pipe is tight. The system must be air-free to ensure the accuracy of the meters.

Liquid enters the inlet of the meter and passes upward into the top of the main casing. It submerges and lubricates the internal gearing; then moves through the measuring chamber. As the liquid enters the measuring chamber, it drives the single measuring disc which nutates (or rocks). The roller, or positive displacement cam, controls its movement and compels it to make a complete nutation at each movement. The position of the disc divides the chamber into compartments which are filled and emptied successively, each compartment holding a definite volume. The movements of the disc are transmitted by a gear train to the totalizer or pulse transmitter.

Register

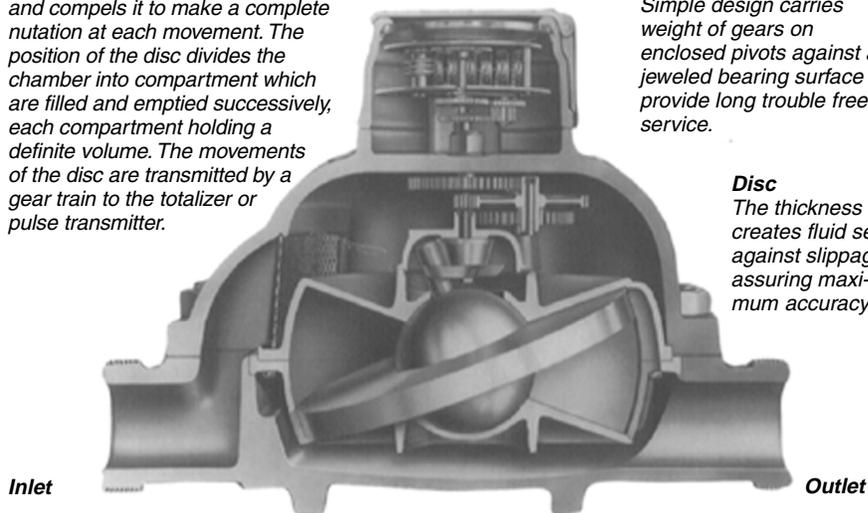
A wide variety of indicating, totalizing, or batching registers for every metering application.

Intermediate gear train

Simple design carries weight of gears on enclosed pivots against a jeweled bearing surface to provide long trouble free service.

Disc

The thickness creates fluid seal against slippage assuring maximum accuracy.



Measuring chamber

Precisely machined to fit the disc. Variations in line pressure will not distort the chamber to affect accuracy.

Principles of Meter Use

The maintenance of volumetric liquid meters is in general so simple that little attention has been paid to it by many users. However, the increasing instrumentation of industry calls for more complete information where many meters are involved. This manual is intended to give definite suggestions on maintenance and repair. In each company using Niagara meters, a single person should be designated to have complete supervision of original installations, maintenance, and repair.

Niagara meters are built in four general classes of construction as follows:

- 1) Cold water (less than 100°F) and cold non-corrosive water-base liquids.
- 2) Hot water (more than 100°F) and heated non-corrosive water-base liquids.
- 3) Petroleum products and other non-corrosive oils and similar liquids.
- 4) Chemical solutions that are corrosive to bronze, but which can be metered by the use of iron case with type 316 stainless steel chambers in meter parts.

Use a meter only on the liquid for which it was ordered. Materials and calibrations are substantially different for each class. Cold water meters will be damaged immediately by heat or oil. Hot water meters may be run on cold water without physical damage but registration will be 1% to 4% inaccurate. Oil meters will be damaged in a day's time by water. Chemical meters are specially constructed for the particular chemical specified.

All these meters operate on the same principle of measurement and are of the nutating disc volumetric displacement type. The liquid enters the meter through the inlet, shown at the left in the sectional view, and passes upward into the top of the main casing. Here it submerges and lubricates the internal gearing; then moves downward through the measuring chamber, into the base of the meter, and discharges through the meter outlet. When the liquid enters the measuring chamber, it drives the single measuring disc, which nutates or rocks, around on its central ball. The roller or positive displacement cam, against which the disc pin bears, controls its movement and compels it to make a complete nutation at each movement. The position of the disc divides the chamber into compartments which are successively filled and emptied, each compartment holding a definite volume. The movements of the disc are transmitted by a train of gears to the meter register.

The edge of the flat portion of the nutating disc is unusually thick. The liquid being measured forms a liquid seal between the disc and the chamber wall, minimizing slippage and compelling accuracy at low rates of flow. Works are made of materials selected for the liquid to be measured. The bearings of the submerged gears carry the weight of the gears on the tops of the gear posts, forming an enclosed, dirt-proof construction.

The amount displaced by a single movement of the disc remains constant for any specified liquid. With the correct train of gears, accurate registration on the register is thus assured. Each Niagara meter is individually tested and calibrated at the factory to run within close tolerances at all rates of flow within its rated capacity, on the liquid for which it is intended. Oil meters are tested on oil and the tolerance is not more than 1%, sometimes much smaller.

Like all volumetric meters, Niagara meters are intended for operation on clean liquids only. Solids such as sediment or pipe scale must be removed before metering by a filter or fine mesh strainer.

Operating Difficulties

This is intended as a guide to tell where first to look and to locate the cause of troubles that may be observed.

REGISTER STOPS

After making sure that liquid is actually flowing through the line when the meter fails to register, the first step is to investigate whether the difficulty is in the register or in the submerged works. Remove the register box or lift a vertical register off its seat and see whether the drive shaft passing upward from the meter body turns when liquid is flowing. If the drive shaft turns, the trouble is then located in the register. If it does not turn, the trouble is inside the meter body which must then be opened.

In relatively new meters, slogging by dirt is a common cause of stoppage and usually requires only a careful cleaning.

If the trouble is located in the register, the most likely difficulty is that the set screw of one of the change (calibrating) gears has come loose, and needs only to be retightened on the flat spot of the shaft.

RUNS INACCURATELY BY A FAIRLY CONSTANT PERCENTAGE

If this percentage of error is not more than about 5% and the meter is not too old, this may indicate either an error of original calibration, or an error resulting from slight wear or change of viscosity of liquid being measured. These can be corrected by following instructions for correcting accuracy. However, once an error due to wear has started to develop, the meter may show a further error within a relatively short time and should be watched.

OVERREGISTERS ERRATICALLY

If the meter registers substantially more than the true quantity of liquid passing through it and particularly if the amount of the over-registration is erratic; this indicates that air, steam or other gases are being passed through the meter along with the liquid. These would register like the liquid. The remedy is to keep the air or gas out at its source, or in certain cases, to install an air release valve ahead of the meter. Changing the calibration of the meter cannot correct this kind of trouble. Once a meter has been correctly calibrated it cannot, of itself, start to overregister; except for a slight and consistent overregistration, of perhaps 1%, may result if a film of scale forms inside a water meter.

UNDERREGISTERS BY A SUBSTANTIAL OR ERRATIC AMOUNT

This may be caused either by severe wear or by partial clogging of the meter due to foreign matter. It is usually advisable to open the meter to see if cleaning will correct the trouble, or if the needed repair is something that can be done on the job. Unless adequate repair facilities are available locally, it may be advisable to return the meter to the factory for repairs.

DIAL HAND TRAVELS ROUGHLY

If the dial hand alternately stops and jumps ahead, this indicates difficulty with the meshing of the gearing, usually in the change gears. The gears may be worn to the point that the tops of the teeth strike on each other, or the gears may be adjusted so they mesh too tightly. In either case, adjust the change gears so they mesh smoothly with just enough clearance to prevent binding, and replace gears if worn.

LEAKAGE OF METERED LIQUID

Leakage of liquid at the point where the register is attached to the meter body, indicates the following: (a) On meters built before 1996, the stuffing box packing has become loose and needs retightening. Follow instruction under *Repacking the stuffing box*, page 9. (b) On meter built after 1996, the mechanical seal has become worn and requires replacement. (c) Temperature may be too high for the seal used. (d) Shaft may have score marks, showing a new top gear and shaft are required.

Leakage around the meter body indicates usually that the operating pressure is above that for which the gasket was intended, or the temperature is too high for the gasket causing it to burn out, or the meter was not correctly assembled after repair. In bronze case meters, it is also possible that excessively high pressure may warp the outer casing permitting leakage midway between the bolts. Leakage at the couplings on the ends of threaded meters indicates that the coupling washer is not holding tight or is missing. Pipe must be correctly aligned to permit the washers to hold tight. Leather washers used for cold liquids will burn out at high temperatures and should be replaced with resilient washers.

Cleaning and Repairing

GENERAL INSTRUCTIONS

Keep all parts of a meter together and do not allow parts to be interchanged. While machining dimensions are such that the parts are physically interchangeable; any interchange of measuring disc, measuring chamber or change gears may change the accuracy of registration of the meter. Keep the register box with the meter body to avoid mix-up of serial numbers. Remember that the meter is a precision instrument and all parts must fit perfectly after repairing. Do not expect to do a real repair job by mere cleaning, for worn parts must be replaced. Meters used on slow flows must be kept in especially good condition.

Use the procedure below for standard inspection and repair supplementing it with detailed instructions following:

Unbolt the meter body and lift off the entire top half of the casing. Lift out the chamber in which the nutating disc moves and separate the two halves, removing any screws which hold the two halves together. Lift out the measuring disc and inspect this for wear, dirt, or chips embedded in it. These must be completely and carefully removed as directed in detailed instructions for disc in the next section.

Next inspect the measuring chamber for wear in the lower ball seat or for rubbing of the edge of the disc on vertical chamber wall. If wear at either point, or evidence of rubbing on the vertical wall is found, the chamber should be replaced, otherwise clean out any dirt and reassemble the disc in the chamber.

Try the register by turning the gearing inside the top casing. If the register hand fails to move or moves irregularly, remove the register from the meter and inspect the calibrating or change gears located just beneath the register base plate. Tighten the set screws of these gears if necessary and see that they mesh squarely but with a little clearance between the teeth to avoid binding.

Replace the measuring chamber with disc into the bottom casing of the meter. Replace the meter body gasket or use a new one obtained from the factory. (Meter body gasket material must not be more than 3/64" thick.) Then carefully set the top casing onto the assembled unit. Be careful to obtain a proper mesh of the gearing when replacing the top casing to avoid damage to the internal gears. After reassembly, a meter of 1.5" or smaller size should operate when held to the mouth and air blown through it. If the stuffing box or mechanical seal has been leaking, or if the top intermediate gear has been removed, reassemble the stuffing box as instructed on page 9.

When repairing 3" IV, 4" JV, or 6" LV sizes, note the top casing. This should be removed before opening the main casing, as the intermediate gearing is mounted on the underside of it. If the top main casing needs to be removed, the cover plate opening provides a convenient place to grasp the main casing. In these meters also there is a measuring chamber cover plate mounted on the disc chamber enclosing the disc pin and the disc pin opening in the chamber top in the same manner that the gear plate does in small sizes.

After repairing meters dispose of the worn parts removed. Do not allow any collection of bad parts to accumulate. They would cause confusion with parts which are still usable.

DETAILED REPAIR INSTRUCTIONS

Discs

Clean off foreign matter avoiding the removal of any of the disc material. If wire brushing by hand fails to put the disc in perfect condition, note the following. Extra-fine emery paper or cloth may be used; but be careful not to reduce the diameter, nor to round the edges, nor roughen the central ball. If made of metal, carefully scrape off any embedded specks of foreign matter. Do not use emery or other abrasives on the central ball if the meter is to be run at slow rates of flow. If the metal disc portion of a disc used in hot water is corroded, clean off any loose products of corrosion. It is not necessary in such a case that the disc be perfectly smooth. On non-metallic discs, test the flatness of the disc portion with a straight edge. If it is warped, the entire disc (either one-piece or the three-piece construction is used) must be replaced. If any portion is swollen so that it does not run freely in the chamber, this must be replaced, for it cannot be remachined. The disc must move freely in the chamber after reassembling, and the ball must be very smooth. In small size meters if there is any doubt about the perfect fit of the disc, replace it. Accurate measurement cannot be obtained with a poor disc.

To separate the halves of an old chamber, remove the screws, if any; then tap diagonally on the wooden surface, holding the chamber bottom up.

In hot water meters, if the disc portion is broken, this indicates that the meter has been run at excess speed probably by passing steam through it.

Testing for wear on disc ball or measuring chamber

If the edge of the disc, or the vertical wall of the measuring chamber, shows marks of scuffing or rubbing on the wall of the chamber at any point (other than obvious grit scratches), this proves that the disc needs replacing. Wear usually occurs about equally on both items so both probably need replacement if either does. This test discloses severe trouble but other wear may be checked by placing the disc in the chamber tightly. Grasp the disc pin in one hand and move the disc up and down to ascertain the amount of clearance. In meters for low temperature service, the vertical clearance should be not more than about .01." In meters for higher temperature the clearance will be slightly higher when tested cold but any clearance greater than about .02" indicates wear to require repairs. By inserting a new disc and repeating this test, it can be ascertained whether the wear was in the disc on the chamber seat or both.

Assembling the two halves of a measuring chamber

The diaphragm serves as the guide to hold the two halves of the chamber in alignment with each other. Using a wooden block or mallet, lightly tap the diaphragm in place in the chamber bottom. Place the disc in the bottom chamber, then place the top half on without the gear plate, in such position that the slots engage the projections on the diaphragm. Tap sharply on the upper edge of the chamber, over the diaphragm, to make sure the chamber top is fully in place.

Diaphragm

If this is worn to the point where the surface is roughened, this would interfere with the accuracy of a meter operated below about 25% of maximum capacity. Try turning the disc in the chamber by grasping the disc pin. If it catches or sticks momentarily on the diaphragm at some point, this indicates that the diaphragm needs attention. As wear always occurs on the side toward the outlet port of the chamber (the port in the bottom half), sometimes the diaphragm can be reversed to present a new clean surface on the outlet side, otherwise it must be replaced. If meters are regularly run at fast flows, a small amount of diaphragm wear will not have so much effect on accuracy. The diaphragm must fit tightly in its slots in the chamber, otherwise slippage will

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occur and the meter will be very noisy. Excess clearance between the diaphragm and the slot in the disc will also create noise, but a little excess clearance does not affect accuracy except at slow rates of flow.

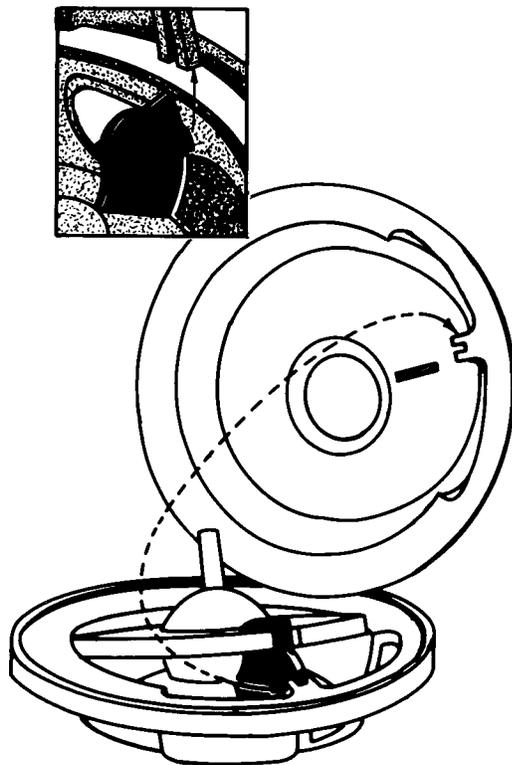
Intermediate gear plate

The shaft with its driver block and pinion must revolve very freely, but without much wear in shaft or bushing. If there is wear, the entire unit must be replaced. The roller also must revolve freely but must not be worn, for wear on this or the disc pin would permit the disc pin to make an incomplete stroke, displacing less than the proper volume of liquid and so causing overregistration. If the roller is worn, other parts of the gear plate are likely also to be worn making complete replacement advisable.

Repacking stuffing box (Meters built before 1996)

After removing the stuffing box nut, take out the old packing. Check shaft to see whether there are score marks. If the shaft is scored, the top intermediate gear and shaft must be replaced. If the hole passing through the top casing is worn, the top casing should be replaced.

Have the top intermediate gear and shaft in place; on this shaft place the new packing, then the stuffing box nut, and tighten it, using the special wrench supplied for this purpose. This wrench permits a downward pressure to be exerted at the same time as the nut is rotated. Tighten the nut just enough to stop leaks. The nut for "O" ring packing should only be tightened to a snug fit. ***Do not overtighten.*** Excess tightening will impose a drag on the measuring parts that will interfere with accuracy of measurements, and cause rapid wear of the submerged gears. If upon opening a meter there is more wear observed on the top intermediate gear and the pinion meshing with it than on the first, or second gears, or the gear plate drive pinion; this usually indicates stuffing-box drag. Test of packing tension can be made by turning the gear inside the meter casing. The gear should turn with some friction but not too tightly.



Replacing mechanical seals (Meters built after 1996)

After removing the stuffing box nut by turning in a counter-clockwise rotation, slightly pressurize the meter and then release the pressure. The pressure will push the seal out of the stuffing box. During assembly locktite was used between the stuffing box nut and the stuffing box. Clean any remaining locktite from the threads. Check the shaft to see if there are score marks. If scored the top gear and shaft must be replaced. If the hole in the top casing is worn, the top casing should be replaced. Have the top gear and shaft in place and using your fingers press the replacement seal onto the shaft, spring side down. To avoid damaging the seal hold it as perpendicular to the shaft as possible. This will stop the leading edge of the shaft from cutting into the seal. Slide the seal down the shaft until it touches the top edge of the stuffing box. **By hand, not using tools**, place the stuffing box nut on the shaft over the seal and tighten the nut. Turn the nut in a clockwise rotation; this will press the seal down into the stuffing box. Remove the stuffing box nut and apply one drop of removable locktite to the external thread of the stuffing box. Replace the stuffing box nut and tighten by hand only (NO TOOLS). This type of seal cannot be tightened to seal a leak.

Position of gear plate on measuring chamber

All meters of 2.5" and smaller sizes have the gear plate mounted directly on the chamber. Place the gear plate on the measuring chamber in such position that the arms carrying the pivots point generally in the direction of the open inlet port in the top half of the measuring chamber. The only exception is the 1.5"—it's reversed.

Position of measuring chamber in the meter body

The measuring chamber should be so placed in the bottom casing of the meter that the outlet port in the bottom half of the chamber is directly in line with the outlet port on the meter casing.

Equipment for Servicing Meters

The amount of equipment required depends upon the extent of repair work to be undertaken. The minimum proper equipment would be as follows:

Three screwdrivers: large, medium, and small, the small one having a fine blade for change gears.

Sockets and ratchets for meter body bolts.

Wire brush

Hammer

Extra fine emery cloth or paper

Scraping tool

Steel straight edge as long as the diameter of the largest meters to be serviced.

The following equipment is also desirable if the number of meters to be serviced warrants its purchase:

Motor-driven rotary wire brush for cleaning rough surfaces. (Do not use this on inside of measuring chambers or on disc.)

Accuracy testing equipment

Supplies that should always be on hand include gaskets and stuffing box packings, or seals for all sizes of meters in use. These should be kept on hand in advance to save time in cutting gaskets or errors of using packing of incorrect material or design. Experience will dictate what other repair parts should be kept in stock or we will make recommendations.

Pressure Tests

All meters are given a hydrostatic pressure test at the factory for two reasons (1) to detect porosity of castings and (2) to check the tightness of gaskets and stuffing box packing.

After shipment from the factory the castings need no further pressure testing against porosity unless used on corrosive applications where the metal may deteriorate. After each repair the tightness of packings should be checked. Leaks at the meter body gasket are very rare if the meter is carefully assembled and testing for such leaks may usually be omitted. For meters built before 1996, the tightness of the stuffing box packing should be checked either by a hydrostatic test before installation or by observing the condition of the meter after a couple of days use when the packing has had time to seat itself in place. For detailed information on repacking of stuffing boxes, see page 9. Be careful that the packing is not unnecessarily tight, as this would cause damage because of excess friction load on the meter works. Meters built after 1996 with new seal requires only finger tightening.

Accuracy Tests and Calibration

PRINCIPLE OF ADJUSTMENT FOR ACCURATE MEASUREMENT

Meters which are apparently identical may vary slightly in the quantity delivered per revolution of the drive shaft passing through the stuffing box. Also, substantial variations of speed of the register shaft are required for different units of registration and different types of registers. Therefore, each meter is equipped with a set of gears known as change gears located immediately beneath the register. Change gears are made with varying numbers of teeth so the different combinations of gears give different speed ratios as needed. This variation in number of teeth necessitates giving the factory the serial number of the meter, and the number of teeth on each change gear, when accuracy is to be adjusted or new gears purchased.

CORRECTING ACCURACY BY CHANGE GEARS

First ascertain the exact amount and direction of error. Unless such tests are accurately run, it cannot be determined whether there is any real error of measurement in the meter. After ascertaining the exact amount registered for a given amount of true quantity of liquid delivered through the meter, make sure that this registration is consistent. An erratic error or a very large error cannot be corrected by change gears and indicates other troubles as suggested under *Factors affecting accuracy*.

Unless a stock of change gears is kept on hand, new change gears must be procured from the factory so the calculation of them should be left to the factory. Notify the factory, telling the serial number of the meter, the amount registered, and the true quantity delivered on the accuracy tests; as well as the number of teeth on each of the change gears now on the meter. At the factory the new set of gears required to correct the reported error will be calculated.

If a considerable number of meters of the same size and dial are in use, we will supply a change gear chart showing the various combinations used on that meter and dial. To use such a chart, calculate the percentage of error and note the number of teeth of gears now on the meter. Then, from the chart, select a new set which will give as closely as possible the desired percentage of change. If your meter is registering less than the true quantity delivered, select a set of gears further down the chart to make it register more. If it already registers too much, select gears further up the chart to make it register less.

FACTORS AFFECTING ACCURACY

Wear

Wear causes a meter to register less than the true quantity delivered. The effect shows up first at low rates of flow. A meter which is somewhat worn may still run almost perfectly at higher flows, yet be inaccurate at slower flows. If the wear is not bad, a temporary correction can be made by fitting the meter with new change gears to bring the registration close to 100% at the average flow rates. If the error due to wear is more than 3%, replacement of chamber and disc is usually necessary.

Change Gear Selection Table for Meter with Dial Making One Revolution of Test Hand for:					
1 Cu. Ft.			20 U.S. Gal.		
Number of Teeth		Change Gear Intervals %	Number of Teeth		Change Gear Intervals %
Register Gear	Meter Gear		Register Gear	Meter Gear	
41	14		41	11	
43	15	2.2	44	12	1.7
45	16	2.0	43	12	2.4
42	15	0.5	42	12	2.4
44	16	1.8	41	12	2.5
41	15	0.6	42	13	5.7
43	16	1.7	41	13	2.4
42	16	2.4	44	14	0.4
39	15	0.9	43	14	2.3
36	14	1.1	42	14	2.4
38	15	1.5	44	15	2.3
35	14	1.3	41	14	0.2
37	15	1.4	43	15	2.2
39	16	1.2			

Chart of change gear combinations for 1" (B) size oil or hot water meter fitted with horizontal register, showing percentage of intervals between gear combinations.

Air or vapor

Passing any gas through a meter including air or steam causes overregistration, because the meter registers the volume of gas as well as the liquid. The only remedy is to keep out the gas at its source or to protect the meter in certain cases by an air release. Change gear compensation is not satisfactory.

Foreign solids

Any solid matter in the measuring chamber of the meter will impede the movement of the disc and cause underregistration. The course of the liquid through a meter is such that the meter will tend to flush itself clean; but if foreign matter comes through the line repeatedly with the liquid, the only way to obtain successful metering is to trap out this foreign matter by a filter or strainer.

Change of viscosity

Meters are shipped calibrated for the average viscosity of liquid specified in the order. In general, it may be said that if the viscosity decreases, (the liquid becomes thinner and more free flowing), the registration in the meter will decrease slightly and if the viscosity increases, the registration will increase slightly. Consult the factory for more detailed information concerning the amount of change to be expected in any given set of circumstances. Viscosity changes resulting from temperature changes of plus or minus 25°F can almost always be disregarded.

Change of temperature

Any Niagara meter registers by volume and is calibrated to register the volume at the specified operating temperature. If the temperature changes substantially, the registration in the meter may change slightly, but this is due to the change in viscosity and properties of the liquid. The effects of minor changes of temperature, amounting to less than plus or minus 25°F, may usually be disregarded. For the effect of the difference between hot water and cold water, see page 15 under *Methods of making accuracy tests*.

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If it is desired to convert reading into gallons as of some different base temperature, the meter readings should be multiplied by a factor representing the difference between the volume at the base temperature, and the volume at the metering temperature. For example, #6 fuel oil expands approximately 1% for 27°F rise in temperature. If oil is measured at 180°F by a meter ordered for such use, and the readings are to be converted into gallons as of 60°F, the expansion between 60° and 180° would be approximately 4.5% so that meter reading should be reduced by 4.5% to obtain the equivalent volume as of the base temperature.

Change of rate of flow

As with all meters the curve of accuracy of Niagara meters when plotted, is a slight curve, not a perfectly straight line. Meters are calibrated at the factory so the registration at varying flows averages as close to 100% as possible. At full flow the meter usually registers slightly less than the true quantity delivered and the proportionate registration increases with decrease in flow rate until at about 5% to 10% of maximum cold water or oil capacity, the meter registers slightly more than the true quantity. At still slower flows the registration starts to decrease until at very slow flows the meter again registers less than the true quantity delivered.

The characteristics of this curve of accuracy vary with meters for different liquids and vary slightly for different meters of the same size and class. If meters are to be used for exacting measurement where accuracy within fractions of 1% is important, consult the factory for details.

Note that when a meter registers slightly high at some flows and slightly low at others, the errors over a period of time at varying flows will tend to cancel out. The total accumulated error may thus be only a small fraction of 1% when the maximum error at certain rates of flow is as much as 1%. Note also the "accuracy tolerance" means the maximum error permissible at any one rate of flow which is usually greater than the maximum error actually existing and is far greater than the usual accumulated error in operation.

FACTORS NOT AFFECTING ACCURACY

Sudden starting or stopping of a meter does not affect accuracy as there is no lag in the movement of the measuring disc.

Pulsating flows do not of themselves affect accuracy. The rate of flow at which the meter operates varies during the time cycle of the pulsation and the meter will register with the usual accuracy for such rates of flow. As pulsating flows reach full rate very quickly, the effect of reduced accuracy at point of slow flow in the cycle of a pulsation can usually be disregarded.

Variations in operating pressure do not affect accuracy as liquids are incompressible and the volume to be measured is unchanged at different pressures. Note, however, that an increase in pressure may speed up the rate of flow causing the meter to register with whatever accuracy would be expected at such different flow.

MAKING ACCURACY TESTS

Types of test equipment

There are three types of test equipment, each having its own advantages as follows:

Weigh tank

The weigh tank is the most flexible testing equipment and is generally recommended for industrial use. This consists of a drum or tank of desired capacity mounted on a scale. The tank is weighed before and after each test

run and the difference in weights represents the weight of metered liquid put into the tank. The exact weight per gallon of the liquid has to be computed separately or in the case of water taken from standard tables for the prevailing temperature and the weighed quantity reduced to gallons, then compared with the meter reading. Advantages of this method are that tests can be made on viscous liquids which would not completely drain out of the tank; tests can be made on widely varying quantities without change of physical equipment and that meters for different liquids can be tested. A movable platform beam scale carrying a 55-gallon drum fitted with means for emptying is most commonly used. The drum is replaced with a smaller container for testing 0.75", 1", or 1.25" sizes.

Volume tanks

These may be of several types. Various companies such as Ford Meter Box Co., Wabash, Indiana, manufacture complete test benches consisting of volume test tanks, orifices for controlled rates of flow, connections for installing the meter to be tested and supporting base. These are widely used for testing water meters and could be used for other liquids, provided the liquid is such that the tank will drain completely. They are not useful on heavy oils, etc. For maximum accuracy a separate tank is required for each quantity such as one cubic foot, 10 gallons, or 100 gallons as the tank should have a narrow neck with gauge glass to show small deviation from correct quantity. When properly used these test benches give excellent accuracy, but are generally not flexible for a wide variety of conditions or liquids.

Variations of the volume tank take many forms. The simplest is the 10-quart or 12-quart pail used to make a rough check to see if a meter is registering somewhere near accurate. Errors in pail capacity and reading the meter makes this method unreliable for results closer than 5%.

Large meters used for delivering petroleum products are sometimes checked against calibrated compartment of a tank truck. This is acceptable provided the calibration has been carefully made, and that tests are always made in the compartment under the same operating conditions. Adjacent compartments in the truck must always be empty. Delivery into the truck must be a hose or pipe of such length that the delivery is made beneath the surface of the liquid, otherwise an error up to 0.5% may be created by evaporation as the liquid splashes into the compartment. If tests made on two different compartments appear to vary, the cause is probably due to error in calibration of one compartment.

Test meter

A test meter gives results with reasonable accuracy subject to whatever error may exist in the test meter. It is simple to use and permits service meters to be tested without removing them from their fitting. It is usable only on the liquid and under the operating conditions for which it was purchased.

RULES FOR ACCURACY TESTS

1) For maximum accuracy, test against a standard such as a calibrated volume tank or weigh tank rather than another meter. However, a portable test meter specially purchased for the purpose will give close results subject to any error within the test meter. Do not use another service meter or a meter of a different brand for testing.

2) Tests should be run at the normal rate of flow at which the meter will be used. A meter used on fast flows should be tested on quantities not less than one minutes running. If used on slow flows, it should be tested on 10 gallons or one cubic foot or one revolution of the test hand, whichever is the greatest amount. Always make tests for complete revolutions of the test hand. On vertical dial meters, set the hand back to zero for each run.

Nutating Disc Meter

3) The control valve must be as close as possible to the end of the line and in any event on the outlet side of the meter. When a test meter is used it makes no difference whether the service or test meter is ahead of the other. If the liquid is volatile—like hot water, gasoline, alcohol, or solvents—the discharge into the measuring tank should be beneath the surface of the liquid.

4) To make a test, run liquid through the meter and piping until all air is surely flushed out; then continue to run the meter while the test dial hand is at zero, or set a vertical dial hand to zero. Next run through the meter the desired quantity of liquid, stopping the test according to the meter reading, rather than according to any indication in the testing device. Measure the amount delivered and compare this amount with the indicated amount on the meter dial to ascertain the percentage of error, if any. Make three tests to be sure that the meter runs uniformly. If variations on tests are small, average the three runs. If large variations are found, investigate and correct the cause, then start the test again. Correct an error by change gears as described in *Correcting accuracy by change gears* on page 13.

If a portable test meter is used as the testing method, flush out the air, run the dial hand of the service meter to the zero point, then set the adjustable hand of the test meter to zero and commence the test. On a test of 100 gallons indicated by the test meter, the difference in number of gallons between the service meter reading and the test meter reading gives directly the percent of error in the service meter.

COLD WATER METER INSTRUCTIONS

Test only on cold water. The standard accuracy tolerance allowed by water works on new meters is plus or minus 1.5% to 2% throughout the total range of flow shown in the table on page 14.

At 1.5% of maximum flow a repaired meter would register 90% or more. A repaired meter has to be in very good condition to run accurately. If tests cannot be made at full capacity it is satisfactory if the meter runs accurately at intermediate rates, for such a meter will then also run accurately at full flow.

HOT WATER METER INSTRUCTIONS

For convenience, hot water meters usually are tested on cold water. As the temperature of the water increases, the lubricity and viscosity of the water decreases. When a hot water meter is tested with cold water, the meter will register less than the actual quantity of water passing through it. Hot water meters having a carbon ball in the measuring disc should register 3% to 4% less than the true quantity of cold water passing through it during the test. Meters having the disc ball made of non-metallic composition other than carbon and intended for use on temperature under 180°F should register 1% to 2% less than the true quantity of cold water delivered. Tests should be run at the rate of flow at which the meter will be used and care should be taken that this is within the recommended range of capacity as shown in the *Niagara Selection Guide*. If the meter reads in pounds, compensation must be made not only for the water characteristics mentioned above, but also for the decrease in specific gravity that occurs with heating.

OIL, GASOLINE METER INSTRUCTION

Meters for petroleum products must not be tested on water. For maximum accuracy they must be tested on the actual product to be measured and at the normal operating flows. If gasoline meters cannot be tested on gasoline by reason of fire hazard and must be tested on some other petroleum product, the factory will on request give a calibration factor which can be used to compensate for the difference in the two products.

Meters for #6 or Bunker C fuel oil may, however, be tested on medium oil such as #3 fuel oil and the following factors of correction applied to give correct volumetric readings on #6 oil at the normal operating temperature. If the #6 oil will be at temperature under 120°F, test the meter on #3 oil to register 2% less than the true quantity delivered. If the #6 oil temperature will be 160°, test to read 1% less than true quantity. If the #6 oil will be at 200° or higher temperature, no correction factor is needed. Meters to be used on kerosene or diesel oil, but tested on #3 oil should register 1% more than the true quantity of #3 oil delivered on the test.

TEST COMMENTS FOR OTHER METERS

For detail test standards for any other liquids, consult the factory. The following may be noted as general guides. Unheated water-base products having low viscosity may be tested the same as cold water meters. This includes many chemicals including dilute sulfuric acid, etc. Oils other than petroleum would be considered the same as petroleum products having equal viscosity. Raw linseed oil would thus be considered substantially the same as #3 fuel oil. Alcohol meters may be tested on cold water to cold water standards. Other solvents would be considered more comparable to gasoline meters and require testing either on the solvent itself or on oil with a correction factor. For other liquids such as molasses or syrups, consult the factory.

SERVICE

To service the meter, contact Venture Measurement Company. Venture Measurement has a full service department.



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