A study to determine the effect of changing technologies in the field of volumetric measurement

A STUDY TO DETERMINE THE EFFECT OF CHANGING TECHNOLOGIES IN THE FIELD OF VOLUMETRIC MEASUREMENT

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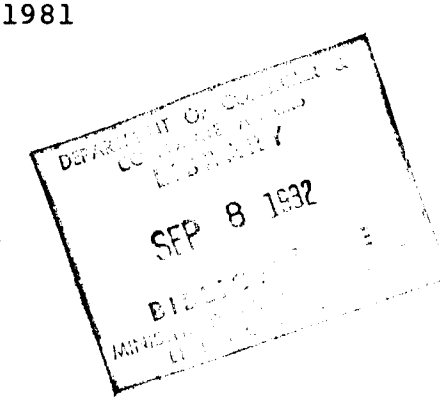

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1.0 INTRODUCTION

This study was carried out during the period January to March, 1981 for the Consumer Research and Evaluation Branch of the Department of Consumer & Corporate Affairs, Canada, under DSS Contract File Reference 03SU.54423-0-314é dated December 19, 1980. The terms of reference for the study were as follows:

1. To review the field of volumetric measurement identifying changing and new technology including amongst others the introduction of electronic measuring techniques and display systems;

2. To forecast the extent and timing of these trends indicating their likely impact upon current regulation;

3. To forecast also any structural and market changes, if any, that might result from the introduction of new technology indicating also their likely impact upon the regulatory situation;

4. To identify and/or forecast any possible developments on the basic principles of volumetric measurement, including developments in the design and use of ancillary equipment such as air elimination, remote registers, etc.;

5. To outline what is known about the plans of other administrations for coping with this technological change;

6. To prepare a report on the findings and conclusions.

The principal statutes and regulations governing measurement for trade purposes in Canada are:

19-20 E.II. Chapter 36, April 7, 1971
The Weights and Measures Act

25-26 E.II. Chapter 55, August 5, 1977
The Statute Law (Metric Conversion) Amendment Act, 1976

P.C. 1974-1461. June 27, 1974
The Weights and Measures Regulations

The study is concerned only with devices that are utilized, in accordance with the Weights and Measures Act and Regulations, for trade purposes whereby the product is sold according to the totalizer reading on a flow meter. Thus it is not concerned with products that are sold either by weight or in

volumetric containers. The relevant section of the Weights and Measures Regulations is Division II - "Volumetric Liquid Meters".

The procedure adopted for carrying out the study involved wide-ranging discussions with industrial representatives, government personnel, meter manufacturers and meter sales agencies. Inevitably, when carrying out an interview program of this type, one listens to numerous beefs but few bouquets. It is pertinent and pleasing to report, however, that during this investigation consistently high praise was expressed in all quarters for the technical knowledge and professional integrity of the Division personnel responsible for the volumetric measurement aspects of Legal Metrology. Complaints were, of course, aired but without exception they related to the lack of personnel and equipment apparently available to the Weights and Measures Division to carry out all the duties for which they are responsible, and not to any serious disagreement over technical issues. While not directly of concern to the specific terms of reference for this study, such difficulties may impact upon the Division's response to changing technologies and are therefore discussed briefly in Section 4 of this report.

In the relatively short time set aside for the study it has been possible to meet with industrial, government and meter personnel in Edmonton, Calgary, Toronto and Ottawa. Numerous additional contacts have been made by telephone. There are, no doubt, gaps in the analysis but it is believed that the most significant trends have been identified.

One area covered by the terms of reference that has not unfortunately been as well covered as was hoped, is the question of practices in other countries. Considerable library research has been carried out but, while it has been possible to refer to copies of the Acts and Regulations applying to the use of flow metering for trade purposes for some countries, it has not been possible to locate articles or information dealing with the primary purpose of the study, i.e., the manner in which such countries are dealing with new technology applications. Contacts made with several embassies and the Delegation of the Commission of the European Communities in Ottawa elicited willingness to help but a uniform lack of pertinent information. Offers were made to seek responses from the relevant country governments to very specific questions but it was also generally noted that such requests for information were more correctly placed through the Canadian Government representatives in the countries of interest. Since it would no doubt take several months to obtain detailed answers to such technical enquiries, this approach has not been followed up during this short study period.

In preparing this report, therefore, references to practices in other countries have been made wherever data were

available. However, since the information that was obtained on approval procedures and experience in other countries was either gleaned from or confirmed by Legal Metrology personnel, the report does not contain a separate section on this subject. We suggest that only a similar type of personal contact with personnel directly concerned, as was adopted for this study, would yield the kind of very specific information desired relating to practices in other countries. Presumably Legal Metrology personnel attend international seminars and conferences on weights and measures issues and it would appear that the most practical way of studying the detailed procedures and manner of handling particular problems adopted in other countries would be during such events.

The successive chapters of this report discuss a number of technical aspects relating to the potential introduction of new metering devices and associated equipment, a review of pertinent flow metering practices and changing requirements in the principal industries concerned and some comments upon current Weights and Measures activities. The key findings and conclusions are brought together in Chapter 5.

2. METERING DEVICES

This chapter contains relevant discussions on some different types of meter that are or may be used for trade purposes, electronic registry devices and automatic temperature compensation.

2.1 Meters

While the Weights and Measures Regulations do not limit a trader to the use of any one type of meter, the performance requirements defined therein refer specifically to positive-displacement meters of varying types and it is this class of meters exclusively that has been fully approved by Legal Metrology for use in Canada.

There is no doubt that positive-displacement metering provides the ideal technology for the vast majority of trade metering purposes. The durability, repeatability and high level of accuracy over an adequate operating range provided by these meters are compatible with most trade applications to protect both the consumer and trader. The enquiries carried out for this study have indicated no sign of any basic desire for change in the very wide use of positive displacement meters for all types of trade applications.

In spite of the finding that an almost exclusive use of positive displacement meters for trade purposes can be expected

to continue into the foreseeable future, a small number of applications do appear to warrant consideration of alternative metering techniques. These applications are discussed in general terms hereunder.

2.1.1 Turbine Metering

Turbine metering, wherein a bladed rotor revolves in a moving liquid stream at a rate that is proportional to the flow velocity, is very widely used in the oil and gas industry and elsewhere for product monitoring and process control. In the gas industry, turbine meters are used for trade dispensing but for oil products such devices are not yet in use in Canada. Fuel oil products are being dispensed in the United States through turbine meters, with an excellent record of performance accuracy but Weights and Measures have so far given approval for a test system to be compared in tandem with the conventional P.D. meter installation on a few fuel oil delivery vehicles.

Turbine meters have to be carefully selected for the product and the range of flows to be metered and the installation is more critical than for most positive-displacement meter applications, in relation to the meter location in the piping system. Meter performance is closely related to flow conditions (which must be in the turbulent range with a minimum Reynolds Number of about 7,000), temperature/viscosity variations and specific gravity.

Experiments in the U.S. have demonstrated that turbine meter installations can be designed for start/stop type operations to remain within normally acceptable accuracy tolerance limits. However, viscosity variations do affect accuracy significantly and in climates such as Canada's where large temperature changes occur seasonally, adjustment factors may be needed to compensate for viscosity differences. Electronic registry and micropressor techniques are invaluable for such installations.

From a regulation viewpoint it would not be satisfactory to approve a meter for trade use without also approving each application for which it is applied. For turbine meter installations where any reasonable range of products and operating conditions may be anticipated, a separate prover for frequent calibration checking is most essential because, while meter linearity and repeatability are excellent for a suitable, carefully calibrated installation, measurement errors increase rapidly with variances from the calibration conditions.

In general, it is the meter suppliers that have indicated a desire to be able to offer turbine-meter based installations at

lower cost for applications where product characteristics are reasonably predictable and can be defined in advance and where pipe proving installations are normal practice. Industry representatives did not in general demonstrate any great enthusiasm for a switchover to turbine meters in such applications. They felt that, in spite of the high costs for large positive-displacement meter installations, such costs were not too significant in relation to the total cost of most pipeline systems and their long and satisfactory experience with such meters, including both reliability and durability, would tend to make them cautious about changing to a technology with much greater inherent variability even allowing for the availability of adequate means to prove calibration accuracy on a regular basis.

It is concluded that turbine meters are suitable for a small number of applications, particularly in the pipeline industry and possibly also for fuel oil deliveries, and will gradually become used for trade-related purposes wherever Legal Metrology can be satisfied that such installations meet acceptable accuracy standards. The initial impetus is likely to arise fom meter manufacturers and suppliers who foresee sales opportunities developing and wish to be in a position to offer less-costly alternative solutions to meet specific metering needs. Our impression is that, for the most part, meter users will have to be 'sold' on the suitability of such devices and are unlikely to consider such alternatives until the meter supplier can provide proof that the devices being offered have received approval from Legal Metrology.

2.1.2 Vortex and Ultrasonic Metering

Most of the major metering manufacturing companies market a range of vortex and/or ultrasonic meters suitable for clear or non-homogeneous liquids depending upon the metering principle utilized. Generally such meters have limited accuracy characteristics but, because of the absence of mechanical features, are frequently used in the process industries for control purposes. They are occasionally used for trade purposes but in most cases are not suitable for that application.

However, a number of liquids or liquid/gaseous mixtures (such as steam for central heating and cryogenics) are conveniently sold using vortex meters because of the difficulty of using other metering techniques. Such commodities are being sold to users based on vortex-meter readings but have not generally come under the purview of Legal Metrology, presumably because of the limited value of such products. Cryogenic liquids

are more conventionally sold in containers by weight but are reportedly being sold in smaller quantities by volumetric measurement for use in soft-drink plants, breweries, hospitals, laboratories, etc. We are advised that such trade transactions are presently exempted under Item 7 of the Regulations but the reasons for such exemptions are not clear. Whether such arrangements meet the other conditions of Item 7 has not been investigated.

Some vortex meters (e.g. the Neptune "Vort-X-Cel" series) measure the velocity oscillations of the flow-sensing element created by vortex shedding in accordance with Von Karman's empirical relationship and transfer these, in the form of a low level voltage to an electronic signal processor. Others (e.g. the Brooks, Series 700 Ultrasonic Vortex Flowmeters) use an ultrasonic beam to pick up the vortex frequency below the sensing element and transmit this frequency in turn to an electronic processing unit. Most such meters claim excellent, trouble-free operation, $\pm$ 1% accuracy over a wide operating range with $\pm$ 0.1% or better repeatability. Providing a vortex flowmeter is used within its appropriate linear flow range at a Reynolds Number greater than 10,000 in the fully turbulent range, its calibration factor is unaffected by viscosity, pressure, temperature or density.

Vortex and/or ultrasonic meters are suitable for a wide range of products, such as slurries, liquid foods, syrups, oils, sewage, and chemicals. While trade applications are likely to be very limited, suppliers believe that metering applications are becoming increasingly attractive for bulk sales by comparision with the gravimetric and volumetric container alternatives. They anticipate seeking limited trade approvals for applications where accuracies of $\pm$ 2% or better are acceptable in view of product values. However, again the response from a small selection of industry representative was generally negative, mostly because no consideration has been given to such applications. Meter companies point out nevertheless that newer industries are using specialist consultants to investigate cost-effective production and marketing strategies and they believe that such changes will in due course be reflected in bulk dispensing practices that eschew expensive gravimetric scale installations wherever convenience and acceptable accuracy can be obtained in a less-costly manner.

In conclusion, it seems unlikely that vortex or ultrasonic meters will or should make significant inroads into the trade arena in the near future. However, while Legal Metrology is reviewing its development options, it would be appropriate to provide for the investigation and testing of a small number of such meters, as and when requested, to ascertain

whether their limited and restricted use for trade purposes of lower-priced commodities may be appropriate.

2.1.3 Magnetic Metering

What has been stated above for vortex meters can generally be considered applicable to conductive flow applications where magnetic metering is suitable, e.g. milk and many chemicals. The demand for trade purposes is not large but accuracies of + 0.5% with good repeatability are claimed over a wide range of flow rates. Magnetic meter performance is also not affected by temperature and viscosity variations.

Apart from the problem of maintaining the electrode contacts clean enough to ensure that pulse pick-up is dependable, the magnetic meter also has the advantage of no moving parts that exhibit wear. However, unlike vortex metering, which can have applications wherein positive displacement metering is clearly unsuitable, magnetic metering is predominantly an alternative to positive-displacement metering. With greater limits of error and some concern over repeatability, it appears unlikely that magnetic metering will find significant application acceptability for trade purposes.

2.2 Electronic Registers

Little more than five years ago, metering devices had not yet entered the electronic age. In 1980, several of the larger players, both industrial and manufacturing organizations, estimate that one-third or more of all new fuel dispensing outlets were equipped with electronic registers. By 1985, the opinion goes, 90 percent of all new installations for gasoline and other fuel dispensing will utilize electronic registry methods. Having discussed this issue with a number of concerned participants, we would have to conclude that, in this area particularly, electronic registry techniques offer sizeable benefits for convenience, ease of operation and lower maintenance and have achieved a large measure of consumer acceptance. For 'self-serve' stations the use of electronic equipment is virtually mandatory and an increasing trend towards the use of such stations in urban locations is evident.

In other cases of fuel dispensing, however, the trends are less clear, while in trade areas not related to the oil and gas industry the advent of electronic registry techniques has yet to occur.

For large gasoline and diesel marketing terminals, which are in a sense very similar to 'self-serve' gas stations, the use

of electronic registry methods is essential for an efficient operation. The computerization of input and output quantity flows and the automation of invoicing that are possible with electronic registry are only part of the management process. The computer is also used to store all relevant product pricing and availability data, identify tanker operators that are authorized to pump product and for a variety of other control and administration purposes. Totally automated control is inevitably the trend in terminal operations.

Fuel delivery is another area where an accelerated use of electronic registry methods can be anticipated. The current procedure whereby mechanical registers with ticket printers are used to control product dispensing and customer invoicing is costly in terms of both equipment maintenance and driver overtime. New installations favour the use of a pulse recorder on the dispensing meter fed to a microprocessor located in the driver's cabin. The processor not only provides an accurate report on all quantities delivered but can be pre-programmed to schedule driver deliveries and provide 'on-the-spot' invoicing of customers. One major fuel supplier forecast that all of the companies fuel delivery trucks would be equipped with microprocessors within five years and that, with the advantages provided by electronic registry, the use of a new metering system for fuel delivery vehicles involving either low pressure-drop turbine type units (for which a test installation approval has been granted as noted in Section 2.1.1) or a specially-designed meter having no moving parts was under study and active research.

Having extolled the considerable virtues of electronic registry techniques, nevertheless, it is pertinent to comment that not all suppliers are convinced that a rapid changeover to electronics is taking place. Meter specialists and distributors that have been in the business for many years conclude that their traditional customers are not dissatisfied with their reliable, mechanical systems that they understand how to maintain, repair and operate. One large national meter distributor that handles several international lines advised that electronic registry units still represent a very small percentage of their total business.

On balance, however, we would have to conclude that for gasoline, diesel and fuel oil dispensing the trend is clear and the advantages of electronic automation far outweigh the disadvantages. In other areas the trend is barely apparent and it would be difficult to forecast any future change on the basis of the current situation. The future possibilitites with regard to milk receiving and propane dispensing discussed hereinafter would certainly lend themselves to increased use of electronic

registry and it may well be that the next big area of growth is in the much wider use of propane for vehicle carburation. Since accurate propane dispensing requires automatic temperature compensation, the adoption of electronic registry and billing techniques is a logical step in that arena, as discussed in Section 2.3 following.

One area of particular concern to both industrial and trade organizations is the question of mechanical registration. Regulation 248 states that "A meter for dispensing liquid for retail sale shall have a mechanical register that is driven directly by the metering elements".

Legal Metrology appears to feel strongly about the need for retaining this regulation in effect and points out that the details of what is considered to be an acceptable mechanical register are open to review since they are not included in the regulations. While Legal Metrology considers it necessary to have a mechanical register available for the use of its inspectors for checking purposes, industry representatives point out that any meter with a "mechanical register that is driven directly by the metering elements" is subject to drag (torque) forces that increase wear and limit long-term reliability and durability. They also observe that mechanical registers are an unnecessary expense when electronic registry is permitted. They are the prime cause of meter breakdown and constitute by far the most important single item in increased repair and maintenance costs. We are advised (and it has not been possible yet to check the veracity of this assertion) that several European administrations permit dual electronic pulse outputs from a meter to be used in determining the quality of product dispensed to a customer (the second as a coincident check on the first) and it has been suggested that Canadian regulations are antiquated in this regard.

A small point that may be of concern, is the question of sustained accuracy and control of the movement of the metering element. A positive-displacement meter functions by parcelling the product being dispensed into slugs of known volume within the meter housing. The action involves rotating and oscillating component parts and it may be that precise sustained control is best obtained with a small torque applied to the rotating components in much the same way that a flywheel is used in a combustion engine. This is acknowledged to be an area of mechanical engineering outside of our expertise, but if the application of a small torque has any merit in positive-displacement metering, the attachment of a simple totalizing mechanical register for independent checking and control purposes may still be highly desirable. We are advised that Legal Metrology has

investigated the effects of varying torques applied to the metering element of a gasoline dispenser and intends to carry out further study on this matter.

2.3 Automatic Temperature Compensation (ATC)

Current regulations (Reg. No. 258) require that when ATC is used with a meter, a separate uncompensated register is also provided to record the actual volume dispensed. Regulation 270 states the permissible limits of error for both acceptance and testing of ATC meter devices and it is observed provides for more rigorous standards to be applicable for 'in-service' inspection after January 1, 1985.

Industrial users and meter manufacturers generally agree that the mechanical expansion-contraction type temperature sensors currently authorized for use with approved meters are neither reliable nor sufficiently quick to respond to changed conditions and hence do not provide an adequate level of measurement accuracy. Again, the use of electronics lends itself to such applications. A temperature-sensitive resistance probe (thermistor) is used to detect temperature variations in the product being dispensed and an electronic processor is used to adjust the volume being metered to standard conditions (normally 15.C). Meter readings could be corrected within the microprocessor, but to meet the regulations, the ATC-processor unit is programmed to print a correction to the volume actually dispensed. Such systems are coming into use in Canada but are not at this time formally approved for customer trade. It would appear to be an area where some attention is required by Legal Metrology to cope with a technology change already to hand.

For gasoline and general fuel dispensing, temperature compensation is not a major requirement. Although a one degree Centigrade change in the temperature of gasoline causes a proportional change in liquid volume of about 0.1 percent, the actual variations averaged over a year are not too significant. A study commissioned by the American Petroleum Institute (Ref. not known) concluded that

> " ... apparent inventory losses or gains due to volume changes can at times be as large as one percent of station throughput during a given month. Annually, however, the inventory changes are much smaller and amount to less than 0.4 percent of station throughput".

The API report provides estimates of greater levels of accuracy for various types of temperature compensation and

concludes that the magnitude of such benefits on a national scale (i.e. in the U.S.) would not be sufficient to justify the cost of installing compensating devices on all service station meters. The report also provides graphical information which would be helpful for station operators wishing to monitor temperature-induced losses and gains but such charts would not, of course, affect his customer billing procedure. The date of the basic data used in preparing this study report is not shown but a constant labour rate of $ 12 per hour was used in computing the cost of modifications to existing meter units. It seems unlikely, therefore, that automatic temperature compensation will become economically attractive for dispensing gasoline and fuel oil products in the foreseeable future except for very large operations handling at least millions of litres monthly.

However, as reviewed in Section 3.1.5, it is anticipated that the next decade will witness a marked increase in the number of vehicles operating on liquid propane gas. HC-5 carburetion grade propane is stored and dispensed for vehicle use as a liquid at a pressure of about 1,800 kPa (i.e. nearly 18 atmospheres). Its volume changes by about 0.75 percent for every one degree Centigrade change in temperature. Thus ATC calibration for propane dispensers is essential. To date, only mechanical ATC devices have been approved by Legal Metrology for use with LPG meters.

3.0 SELECTED INDUSTRIAL APPLICATIONS

Within this section of the report are brought together the various aspects of trade metering that pertain to the principal industries concerned.

3.1 The Oil and Gas Industry

In terms of the numbers of trade meters in use and the activities of the Legal Metrology Branch, the oil and gas industry is by far the most significant. Weights and Measures inspectors are generally most familiar with this industry and have followed its development closely. Regional offices have confirmed that a very high percentage of their activities is devoted to approval, testing and inspection of oil and gas metering installations. For convenience of discussion the following subdivisions are used:

- gasoline and diesel fuel dispensing;
- fuel oil delivery;
- bulk metering;
- pipeline applications; and
- propane dispensing.

3.1.1 Gasoline and Diesel Fuel Dispensing

Continued exclusive use of positive displacement meters for gasoline and diesel fuel dispensing at service stations may be anticipated. The accuracy, repeatability and reliabilfty of such equipment cannot be matched by alternatives and there would appear to be no need for the Branch to consider alternative metering technologies at this time.

A very significant increase in the use of diesel fuel, at the expense of gasoline, for road vehicles is forecast (see Ref. 2 and Section 3.1.5) so that an increase in the number of new diesel dispensing outlets can be anticipated over the next two decades.

A continuing trend towards the use of electronic registry techniques may be anticipated. A preference within the industry for the use of electronic display counters rather than mechanical registers is evident. If Legal Metrology can satisfy itself concerning the reliability of electronic pulse technology for use with positive displacement meters, as discussed in Section 2.2, it would appear desirable that they give early attention to the merits or otherwise of relaxing their regulations with regard to the need for mechanical registers unless tests show that they are desirable for stability purposes and essential for the use of Inspectors.

3.1.2 Fuel Oil Deliveries

In eastern Canada where it may be anticipated a large number of homes will continue to use fuel oil for home heating, it may be anticipated that the industry intends to continue its trend towards automation and particularly towards the use of microprocessors for recording of deliveries from road tankers and for 'on-the-spot' billing of customers.

Some industrial representatives have expressed concern over the relatively high cost of repair and maintenance for the standard positive displacement meters used on delivery vehicles for dispensing fuel oil and have suggested that a simpler meter, perhaps of a turbine design, would be attractive. One major company is reportedly giving consideration to a new meter for use on delivery vehicles that has no moving parts, but is not yet prepared to offer a time-frame for the introduction of such a device. Generally, it would seem that in this area Legal Metrology should be prepared for a continuing acceleration in the use of electronic registry devices. Numerical forecasts are not available but one major company anticipated total conversion to microprocessors within five years.

In western Canada those residences still using fuel oil for heating purposes appear likely to change quite rapidly to the use of liquid petroleum gas (LPG), particularly propane. Thus an increase in the use of truck-mounted LPG meters can be anticipated. The specific aspects surrounding the use of propane for vehicle carburetion are discussed in Section 3.1.5, but it is understood that in general the flow metering of propane in Canada is not satisfactory at the present time. Furthermore most regional offices of Legal Metrology are ill-equipped to handle the routine testing and inspection of such systems. This latter question is discussed in Section 4 of this report.

3.1.3 Bulk Metering

The road tankers used for delivery of gasoline, fuel oil and other products to individual customers obtain their supplies from bulk metering terminals. As product prices continue to rise, terminal operators seek greater accuracy in monitoring total product flows. The result of this concern is that automatic temperature compensation (ATC) for these large metering devices appears likely to increase. In view of the limited accuracy of mechanical ATC devices, and the desirability for total automation of bulk facilities, terminal operators prefer to use electronic ATC equipment. It is understood that Legal Metrology has not granted formal approval for electronically compensated metering equipment, although such devices are in use. The Branch should therefore take steps to test, and if appropriate approve, electronic ATC equipment for use in the future. There are, of course, other applications for such equipment as discussed elsewhere herein.

3.1.4 Pipeline Applications

Most pipeline applications involve either direct company deliveries or inter-company custody transfers of product from one location to another. Industry representatives understand that, under the Weights & Measures Regulations (Item 7), the devices used to measure product flow under such conditions are exempted from the approval and routine inspection requirements of the Act but should be operated under an agreement between the parties concerned that is satisfactory to the Minister and in accordance with certain defined conditions. In particular the use of non-approved meters is understood to be permitted by mutual consent.

There appears to be a general belief and anticipation that turbine meters would be valuable for some pipeline applications because of their much lower cost, particularly in the larger sizes frequently needed, and because of their ease of

handling, maintenance and installation and their potential for low limits of in-service error. However, as discussed in Section 2.1.1 the achievement of a high level of accuracy in turbine metering, particularly with crude oils and other viscous hydrocarbons, requires that the metering installation be separately calibrated for each significant change in type of product or operating condition.

Thus, if turbine meters had to be approved for pipeline applications, the approval regulations would have to be specific with regard to the manner in which such meters were used and the requirements for recalibration would have to be carefully defined. While Legal Metrology may not have too much difficulty recommending the Minister's approval for inter-company turbine metering installations in accordance with mutually-acceptable agreements, it would appear to be difficult to grant a general approval for turbine meter use in all trade applications. Thus, it would appear that both industry and government are best served by retaining the exemptions contained in Article 7 of the Regulations. If there were to be an industry request for general approval of a turbine meter or for a metering installation, Legal Metrology would have to consider whether such applications could only be approved under special regulations.

3.1.5 Propane Dispensing

Because it appears to be the only petroleum product that will show an increasing surplus over the next twenty years, governments in Canada are showing much interest in the market potential of propane as a motor fuel (2). The current worldwide surplus is already 15 mbd (million barrels/day) and thfs is expected to rise to over 650 mbd by 1985. The Canadian surplus at the present use level would be some 70 mbd by 1990.

Propane is not yet widely used as a fuel for carburetion in Canada. Statistics Canada data (57-003, 1979) show a total use of about 1,000 bbls/day for road transportation and urban transit. Of the estimated 8,760 vehicles using propane, 57% were in Alberta and 32% were in British Columbia. Usage to the east of the Manitoba/Ontario border was negligible. In Canada as a whole the ratio of propane to gasoline use by volume was only 0.15%. For comparison the equivalent ratio for diesel to gasoline is 3é%.

Nevertheless, a demand for propane can be generated by the use of appropriate conversion incentives. In Holland the propane/gasoline use ratio is over ten percent and in Italy the butane/gasoline ratio is over seven percent. The propane/gasoline ratio in the U.S. is 0.92% and is increasing, mostly in California and Florida where expanding commercial fleet operations are being forced to convert to propane fuels.

In support of their "off-oil" objectives, Government Task Force studies are in progress to consider what inducements may be appropriate to encourage conversions (1, 3, 4). Ontario has reportedly adopted a modest goal of having 40,000 road vehicles using propane (exclusively fleet operators) by 1985. Transport Canada studies are considering the impacts of various incentive policies that could result in as many as one million vehicles using propane by 1990. Since these studies are still in progress, the situation is quite fluid and any forecasts of the total need for liquid propane dispensing by the end of the 1980's decade would be premature. Recently published estimates (2) suggest propane/gasoline use ratios of 1.09% in 1990 and 1.64% in 2000, but it is understood these were based on limited fleet conversion assumptions only and are being revised upwards. However, even these estimates forecast a period of rapid expansion that could have a significant impact upon the flow measurement activities of Legal Metrology. It may also be of some importance to note that, in terms of new installations, the diesel/gasoline consumption ratios are forecast, in the same reference, to increase to 59% by 1990 and 92% by the year 2000. In anticipation of future workload requirements, Legal Metrology will need to keep abreast of these planning developments.

The marketing requirements for increased use of propane in Canada have reportedly not yet been given serious consideration. Most published information relates predominantly to fleet conversions and, since many fleet operators use private refuelling facilities, frequently without metering, the impact of such a trend would not be great. Nevertheless, should the Government decide to use more comprehensive inducements, the impact on commercial dispensing outlets could be significant. Discussion with a propane conversion organization in Edmonton indicated that perhaps one-half of the 130 conversions completed in the last year were to non-fleet vehicles. A similar station in Ontario confirmed the same experience although acknowledging that total numbers were still very small. Both operators expressed the opinion that appears to be held by those involved in the studies that inducements will have to be significant before large numbers of conversions (at a cost in the order of $ 1,500 each) can be expected.

Although Legal Metrology has authorized the use of suitable positive-displacement models for LPG metering, we are advised that the present level of flow metering technology in Canada is considered inadequate to meet the needs of an accelerated program of propane dispensing. It is also apparent that the regional offices of Legal Metrology are not yet equipped or adequately prepared technically for a significant increase in the trade use of LPG fuels.

In Holland, B.K. Gas (a Shell subsidiary) is solely concerned with the retail marketing of propane and has gained a lot of experience in this area. This organization has reportedly offered assistance to Canada in considering the marketing aspects of propane dispensing. The Road Research Laboratory in Holland has also been active in this area. The Branch may wish to follow-up with these organizations in the Netherlands as it seeks to prepare itself for a gradual increase in the number of installations to be insepcted. Limited activity in the introduction of improved metering devices for approval certificates may also be anticipated.

3.2 Agricultural Applications

In Canada the great majority of agricultural products are sold by weight and are consequently not the subject of this study. For the most part even liquid agricultural products are dispensed either in authorized containers with predetermined volumes or in tankers which are weighed before and after dispensing to determine the quantity of product traded. However, a small number of agricultural products are being sold through flow meters and there would appear to be a potential for a small increase in this trend. Specific applications identified during this study are discussed hereunder.

3.2.1 Fertilizers

Until very recently all fertilizer sales in Ontario were reportedly according to weight only. In the Prairies, however, it has been the practice for some time to dispense liquid fertilizer, such as nitrogen and ammonia solutions through a flow meter. The reason for the difference in practice would appear to be that in the Prairies large distances are involved and it is impractical for road tankers to return to a weigh scale after each individual customer is served.

Generally the dispensing of aqueous fertilizer solutions from tankers does not present particular problems except in the selection of suitable meters constructed of non-corrosive materials. However, increasing use is being made of anhydrous ammonia - a liquid gas that is dispensed under pressure. It is a 'dry' fluid and the wear and tear on the meter is considerable. For billing purposes it is usual to adjust the volume actually dispensed to standard temperature and pressure conditions and to invoice the customer in weight units based on the adjusted meter reading.

Truck-mounted commercial meters are approved by Legal Metrology for use with anhydrous ammonia. Since the fertilizer application season is very short, usually not more than a month, it is customary to strip and clean the meter after each season's use and to have it recalibrated in time for the following season.

We are advised that one large supplier recently purchased more than 20 meters for installation on road tankers dispensing anhydrous ammonia in Ontario on a trial basis. If the system proves to be satisfactory, (and there is no reason to believe that it will not) it may be anticipated greater use will be made of these meters on road delivery vehicles because this is a difficult product to handle and the company sees merit in reducing the number of bulk distribution points.

Routine testing and recalibration of meters to be used for anhydrous ammonia is apparently most conveniently carried out using a pipe prover that can be inserted into the delivery line where product is being dispensed. It may be anticipated, therefore, that as Legal Metrology acquires pipe provers for use in routine operations, it will become more convenient to authorize the use of larger devices than the small meters now approved, and to inspect them regularly as required.

3.2.2 Feed Supplements

The study has not identified any significant use of meters to measure liquid feed supplements for trade purposes. Indeed, we are advised by Agriculture Canada that, under the Fertiliser Act and Regulations, all agricultural products must be sold either by weight, or by gallons in marked containers. Some supply agents apparently use small meter pumps to measure product into containers but it is understood that the latter are sold by weight.

3.2.3 Herbicides

Some attempts have been made in Western Canada to dispense liquid herbicide such as Treflan (manufactured by Eli Lilley) and Avidex (manufactured by Monsanto Chemicals) through a meter for mixing with fertilizers. Such practices are not approved but some meter suppliers have questioned whether approval for such practices could be obtained.

Discussion with one of the key manufacturers indicated that the company was only permitted to sell liquid herbicides by weight (in precalibrated containers) and that it was against its policy to dispense such products by any other means. It was pointed out that such concentrated chemicals are dangerous

products and that strict regulations are essential for handling to prevent loss and/or contamination. In the future they anticipate even more rigorous control of packaging and marketing practices and whilst they have no direct control over the actions of their marketing agents, would strenuously resist any attempts to market by any other means than in closed containers. If the above precautions are deemed essential, then it would be desirable for Legal Metrology to continue to discourage the dispensing of herbicides through meters for mixing with fertilizer products. Approximate measurement by pouring from original packing containers would seem to be quite practical.

3.2.4 Oils and Oil Seeds

Discussions with organizations in the oils and oil seed business indicated no preference for measurement by flow rate for marketing purposes. Whilst volumetric filling methods for batching have been tested, they have generally not proved to be satisfactory, particularly as oil density varies with temperature.

3.2.5 Milk

Over the years considerable difficulty has been experienced in developing satisfactory procedures for measuring milk transfers from producer to processor. The precise manner in which this activity is currently handled varies somewhat from province to province but generally involves the initial measurement of producer quantities in calibrated bulk farm tanks, wherein a dipstick is used to record the volume. The contents of these tanks are then pumped into a road tanker for transfer to the processor. Most large processors use approved metering systems for measuring the volumes of milk received, but many smaller dairies continue to use weigh scales for recording milk receipts.

The Ontario Milk Marketing Board (OMMB) controls the measurement of product volume at the producer's bulk tank and arranges for the transfer of product to the processor, generally under contract to a vehicle tanker operator. The processor is required to pay the producers according to the bulk farm tank dipstick measurements which may vary in aggregate from the totalizer readings obtained from their receiving meters. At the end of each month the OMMB compensates the processor for any shortfall between the amount received according to its meter readings and the amount for which it is required to pay. The OMMB monitors these differences and investigates any signficant variations. Farmers' tanks are checked regularly and recalibrated if necessary.

A few years ago a study was conducted in the Guelph area to assess the value of milk meters for receiving products, both from the farm tanks to the mobile tanker and from the tanker into the plant.(5) Over a three month period the volumes received were estimated by four methods:

- plant billings based on bulk tank calibrated dipstick readings,
- dipstick measurements from recalibrated farm bulk tanks,
- truck-mounted receiving meters,
- plant receiving meter.

The plant receiving meter readings were adjusted daily using a 300 gallon prover tank provided by Weights and Measures. Based on the data for 38 loads, involving some 5,250 hectolitres of milk, the results were as follows:

	Farm to Truck	Truck to Plant
Mean shrinkage according to plant billings	0.453%	0.159%
Mean shrinkage according to farm tank readings	0.301%	0.159%
Day-to-day variations in shrinkage		
Minimum	- 0.15 %	- 0.64 %
Maximum	+ 0.76 %	+ 0.73 %
Standard Deviation	0.237%	0.307%

Detailed analysis of the test results on a per day and per shipper basis revealed that individual shippers tended to register consistently high or low deliveries, relative to the meter readings, but that overall, the accuracy based on the dipstick measurements was within normal capacity limits for bulk transfers. On the basis of these results the OMMB would not expect to achieve consistently improved accuracy using truck-mounted meters and believes that its policy of regular inspection of farm tanks (and recalibration when necessary) represents a practical, manageable compromise.

Nevertheless, a system whereby a dairy pays not for the amounts it receives but for the amounts the producers ship is inherently unsatisfactory and in the long run there would appear to be benefit in paying producers according to an accurate measurement of the amount received from each. Such a procedure would involve the use of milk measuring meters on all receiving vehicles.

This practice is apparently being tested in the Maritimes and has reportedly been used for many years in Finland, Germany, Holland, Ireland, Scotland and other European countries. It is difficult to forecast the extent to which such a procedure is likely to gain more general acceptance in Canada but, in view of the cost to the smaller dairies of installing their own meter receiving systems, there would appear to be merit in such a trend.

Under Article 4 of the Weights and Measures regulations, milk measuring tanks for farm use are expressly exempted from approval and inspection under the Act, and the Division is certainly not equipped to tackle such a massive increase in workload if this exemption were to be removed. Legal Metrology has taken steps to resolve this dilemma but in the process has found it necessary to devise a suitable metering installation that they can approve for receiving use in dairies. However, in those provinces where the processor pays the producers according to the farm tank measurements instead of his own meter readings, the latter would appear to be 'non-trade' devices and therefore not subject to the Act and Regulations.

This places Legal Metrology in a difficult position as having jurisdiction only in those provinces where processors pay according to approved meter readings. One solution might be to exempt all milk transactions under Article 7, on the basis that both Parties give notice to the Minister that they have an acceptable agreement between them which, in this case, would be monitored by the Milk Marketing Boards.

In view of the apparent dissatisfaction in some quarters with the present practices, there may be merit in Legal Metrology undertaking a national study of this matter to assess whether the need for a consistent policy would be appropriate. In any event, a forecast of effects that changing technologies (to metered trucks) or different procedures would have cannot be made while such uncertainties remain.

3.3 Cryogenic Liquids

As previously noted, cryogenic liquids are very difficult to measure accurately and there are, at present, no approved metering devices for use with such liquids. Trade transactions involving cryogenics are currently exempted under Item 7 of the Regulations primarily because an approved meter does not exist. However, as the level of trade increases, and new products come to market, it may not be desirable for Legal Metrology to continue to exempt such liquids from the provisions of the Act

only because accuracy standards that are applied to other products cannot be duplicated with cryogenics. Section 3.34 of NBS Handbook No. 44 for instance adopts significant wider tolerance limits for cryogenic liquid measurement devices.

This study has not included any specific investigation of new applications in the cryogenic liquid field with the exception of hydrogen as a potential future motor vehicle fuel. We are advised that a small number of installations have been completed or are being considered, including supplies of various gases to hospitals and laboratories and for refuelling oxygen and other gas cylinders in metal-working shops.

Hydrogen is not presently used commercially as a motor fuel in North America but has been in use in Europe on a small scale for some years. A number of potentially-attractive opportunities are being considered but most of these are unlikely to enter Weights and Measures jurisdiction over the next decade. Ontario has budgeted some $6.4 million over three years with a view to converting some transit vehicles to hydrogen fuel, and since liquid hydrogen can be transported easily by rail, is considering the merits of hydrogen-driven engines as an alternative to electrification of the main rail system. It is anticipated that, by 1987, major airports will be equipped to dispense hydrogen for aircraft refuelling.

Some tests with a dispenser for refuelling automobiles have been carried out in Germany (Ref. 6) with a view to demonstrating that safe handling of liquid hydrogen is possible with relatively unskilled operators, but not to the concerns of accurate metering. The author of this Reference makes no mention of metering the flows being dispensed. It is understood that no research is presently underway in Canada to assess the probable future demand for hydrogen fuel by private and commercial organizations and that no thought has yet been given to metering techniques or installations for trade purposes.

4.0 IMPLICATIONS OF CHANGE

Extensive discussion with persons concerned with the many aspects of flow metering has confirmed that, in general, consumers are well served under the existing Act and Regulations. While a small percentage of those contacted were critical of Legal Metrology as a result of one or more actions taken by the Branch that were considered to be "trade-restrictive", the general consensus we have gleaned from our investigations is one of approval based upon good technical analysis and sound judgement.

Nevertheless, it appears evident that the increasing volume and complexity of the flow metering business, as it relates to trade applications, has begun to outstrip the ability of the Weights and Measures Division to keep abreast of their

workload. Not all areas of the country were visited, and it is recognized that some regions are better equipped with both personnel and facilities than others. However, many trade metering facilities are not being inspected as frequently as the Act and Regulations require and for some applications, suitable routine testing equipment is not available. Laboratory facilities in Ottawa for testing and analysis of new metering devices are reported to be inadequate.

Over the last year, separate management studies of the operations of Legal Metrology have been in progress. It is not known what recommendations arising out of these studies will be adopted and, in any event, this area of concern is outside the terms of reference for this study. Nevertheless, some general findings arising from these investigations will impact upon future Branch operations and are identified herein in the belief that they will be helpful to those responsible for implementing change.

4.1 Approvals of New Devices

It is reported that minor modifications to metering devices that have previously been approved are normally authorized for use by Weights and Measures within an acceptable time frame. Delays in receiving such approvals are invariably caused more by the failure of manufacturers' agents and suppliers to provide adequate information than by tardiness on the part of the Division. Occasionally, however, when new devices are introduced, meter supply companies have had cause to complain of very lengthy delays in receipt of approval. Frequently, authority for the trade use of such new devices comes in the form of only temporary approval to test a limited number of units in service for an extended period before final approval is granted. Such procedures are considered by some to be restricting trade and a reason for undue expense when introducing equipment. This is felt to be particularly frustrating when the device in question, frequently U.S. made, has already been approved for use in accordance with National Bureau of Standards criteria and has a significant history of satisfactory performance under one or more U.S. jurisdictions that can be demonstrated by the applicant.

There are a number of issues concerned here. Firstly, it would seem that more than one year to obtain approval of a new device is unreasonable. If the reason involves lack of facilities for testing (or perhaps for subsequent "in-service" inspection and calibration checking), then the Weights and Measures Division requires either larger facilties or more freedom to use private laboratories under contract. Clearly the Division must have suitable laboratory facilities to test,

analyze and calibrate any metering devices that are proposed for trade purposes and a suitable complement of technical specialists to carry out the work effectively. Outside of this basic requirement, however, it would be in conformity with Government "Make-or-Buy" criteria to utilize private laboratories and non-aligned experts to undertake overload work on their behalf. In view of the growing use of electronic processors for meter registry, the Division has need of regular access to expert advice in this specialist technology.

On the question of standards of acceptance for metering devices, we are advised that Legal Metrology normally accepts equipment that has been approved by other recognized authorities if the supplier can show that it has performed satisfactorily in service. The importance of this factor in keeping down equipment costs is emphasized in the NBS Handbook No. 44 (Ref. 6). In a few cases, however, it is reported that fully tested devices from outside of Canada have not received approval from Legal Metrology until comprehensive testing and inspection here have been completed. It would appear reasonable that, providing acceptable performance can be demonstrated in accordance with Canadian requirements of accuracy and repeatability, then automatic approval could be granted subject only to satisfactory 'in-service' experience over an acceptable period. This period might be from two to five years covering at least two routine checks by a Branch inspector.

One other consideration brought to our attention by several suppliers is the matter of equipment design. Some manufacturers consider it unreasonable to be required to divulge precisely how their equipment functions and consider that performance specifications only are appropriate for regulatory purposes. They suggest that, if the supplier is prepared to guarantee to the purchaser that the equipment will meet accuracy, repeatability and reliability criteria defined by Weights and Measures over a pre-determined inspection interval, it should not be a matter of concern to the Division how the device operates. They also consider that it is not the responsibility of inspectors to understand how the equipment functions providing the owner's manual specifies clearly how the calibration may be adjusted (by the owner or inspector) if necessary during a routine inspection visit.

We have some sympathy with this viewpoint but acknowledge no expertise in this area of technology and refer to it here for consideration only. If this approach could be adopted as a matter of policy, the workload of the division would presumably be lightened, thus permitting more rapid approval of new devices. Obviously, however, if suitable experience data do not exist, this approach to approval of new equipment would not be acceptable.

4.2 Routine Inspection of Metering Installations

While conventional proving tanks are the logical and efficient method for routine calibration checking of metering devices 'in service', such equipment is very bulky and cumbersome to use on the road and cannot readily be utilized with some liquids that are dispensed for trade purposes. For meters larger than 2" or 3" in size, the duration over which calibration tests can be conducted using portable tank provers is barely adequate for satisfactory checking.

Many commercial organizations utilize "master meters" which can be routinely recalibrated in the shop for periodic checking of their 'in-service' meter installations. However, it would probably not be efficient or economic for Weights and Measures inspectors to have sufficient suitable 'master meters' to cover all of the various liquids they are required to inspect regularly.

The other method of calibration utilized widely, particularly in the oil and gas industry, is the pipe-prover. This equipment works by inserting it into the product delivery line and hence does not require the availability of a separate source of the product to be inspected. The procedure is particularly useful for liquids dispensed under pressure, for larger installations where a tank prover has insufficient capacity and for liquids that are difficult and dangerous to handle. Legal Metrology is presently considering the purchase of a small pipe prover and has plans to obtain additional (and larger) units in the future. This approach appears to be essential if the Division is to catch up with present demands for routine inspection and testing of such products as anhydrous ammonia and liquid propane, and it is appropriate that the need for such equipment in all regions be addressed without delay. Wherever turbine meters are to be used, pipe-provers are much superior to tank-provers for calibration checking.

It has been pointed out that even when "master meters" or "pipe-provers" are utilized for checking trade installations, it is necessary to have a tank available into which the product can be pumped temporarily while testing is in progress. No doubt, under many existing situations, this would be necessary but it does not seem unreasonable for Legal Metrology to require that, in future, larger installations that would be tested periodically with a "master meter" or "pipe-prover", should be designed with this requirement in mind. Wherever testing can take place during the dispensing of a product, it would not be difficult to arrange for the calibration device (situated on an inspector's

truck) to be inserted into the delivery line in tandem with the installed meter. In other cases, a separate hose or pipe could be supplied significantly to return product directly to the tank from which it was being pumped. As a last resort, Weights and Measures could have available (or rent as needed) a suitable tanker for use periodically whenever a batch of such larger devices were due for routine testing.

Discussions with a number of regional Weights and Measures personnel indicated some concerns not only over a shortage of staff to cover all of the installations that should be inspected and re-calibrated routinely, but also with regard to a lack of technical expertise amongst some inspectors that would enable them to understand fully the equipment they inspect. It is recognized that the Division does have a small complement of specialists to handle technical problem issues but, in view of complaints that the dissemination of complete technical data about newly-authorized devices does not routinely penetrate to all regional staff, it may be appropriate to conduct more technical training sessions for Divisional inspectors. This relates directly to the question of whether it is necessary or desirable for inspectors to understand how the equipment works and whether it is necessary for them to be able to adjust devices 'in service'. If this ability is considered to be necessary, then regular training sessions are essential.

Records of work breakdown by industry were not readily available, but it is understood that a high prcentage of staff field time is spent in routine inspections of gasoline, diesel and fuel oil dispensing systems as well as in witnessing calibration checks on new equipment at suppliers/manufacturers' premises. Since we have determined that it is in the oil and gasoline dispensing areas that a much wider use of elecronic registry methods can be anticipated, the training of inspectors not familiar with electronic technology would appear to be essential.

5.0 SUMMARY FINDINGS AND CONCLUSIONS

The principal findings and conclusions arising out of the investigations are believed to be in conformity with the anticipations expressed by Legal Metrology at the commencement of this study. As noted in the report, the Weights and Measures Division - Flow Metering Section - has a broad depth of knowledge and understanding of the industry in Canada and it is anticipated that most, if not all, of the trends identified herein coincide with their own expectations.

5.1 New Devices

- It is unlikely that there will be a significant increase in the rate of applications for Weights and Measures approval of new metering devices within the foreseeable future.

- Most requests for approval of new devices to be utilized in the gasoline, diesel and fuel oil dispensing areas will be concerned with the introduction of electronic registers and microprocessors to metering units that have already received approval for use with mechanical registers.

- There will be more pressure from industry for Weights and Measures to relax its regulations with respect to the mandatory use of coincident mechanical registration wherever electronic equipment is being authorized.

- The advent of electronic technology into the metering field provides excellent opportunities for improved product monitoring and control. Accordingly there will be a gradual increase in the complexity of microprocessing units applied to meters including electronic automatic temperature compensating devices, for which Division approvals will be sought.

- Since Legal Metrology does not have access to a Canadian national standard (similar to NBS Handbook 44) covering flow meters, it is responsible for setting the standards according to its own expertise and experience. The present Regulations under the Weights and Measures Act provide performance criteria for certain types of positive-displacement flow meters only but do not contain any reference to other kinds of metering device. Industry finds this system difficult to work with because each device put forward for approval appears to be considered on its own merits (as interpreted by Legal Metrology) instead of against a uniform standard. Consideration should be given to adopting a series of formal performance requirements for all types of application that will permit industry to consider alternative metering devices that may meet such criteria at lower cost in specific circumstances. There is also a pressing need for a standardized statement by W. & M. of their full and detailed requirements from all applicants when approval of a new device is being sought.

- Over the next five to ten years, a marked increase in the use of both diesel and liquid propane fuels for

vehicle carburetion can be anticipated if Government inducement programs now under consideration are implemented. With reference to new devices, an increase in the applications for approval of improved, LPG meters with electronic ATC can be anticipated, but the rate of increase will depend very much on whether incentive programs favour only fleet operators or include private and small commercial vehicle owners.

- The use of larger, more-carefully controlled, centralized agricultural supply terminals will lead to the wider use of vehicle-mounted liquid dispensing systems. At the present time, an increase in the sale of anhydrous ammonia through such meters can be anticipated because of the difficulty of handling this product at smaller distribution centres and the increased use of this fertilizer for agricultural applications.

5.2 Operating Considerations

- In many provinces, dairies and milk processors pay producers for the product received according to the volumes measured in the latter's bulk tanks (even though they have a weigh scale or milk meter receiving system for recording total incoming deliveries). Since these farm tanks are expressly exempted from the Weights and Measures provisions under Regulation 4, it would appear that Legal Metrology has decided not to exercise direct control over milk producer sales. It therefore appears to be illogical for Weights and Measures to approve and inspect processor meter installations and it should consider retiring completely from this area of concern. Even in situations where processors insist upon paying producers according to actual receipts (presumably pro-rated from bulk tank aggregate measurements) the Milk Marketing Boards act as authorized intermediaries and are equipped to negotiate agreements between the parties concerned. With such agreements in place, these milk metering installations should be exempted under Regulation 7.

- In most European countries, milk is metered into road tankers from the producers' tanks in the reverse manner to which fuel oil is delivered to customers in Canada. The adoption of similar practices here would seem to be desirable in view of the disagreements and dissatisfaction existing generally in the industry. Such vehicle-mounted meters would then become the

responsibility of Legal Metrology. However, such meters are not presently favoured in most Canadian Provinces and until there is a move in this direction, it would appear that the Weights and Measures Division role should be only advisory.

- Many approved metering installations are not presently being inspected and tested in accordance with Weights and Measures Regulations. This is due to both staff and equipment deficiencies. Attention needs to be given to filling staff vacancies, acquiring new equipment such as pipe provers to improve calibration checking efficiency, considering the wider use of contract sources to carry out routine inspections at appropriate fee levels, and technical training seminars to acquaint inspection personnel with the details of newly-authorized metering devices.

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