Temperature Compensation of Liquid Fuels

A Study for

National Weights and Measures Laboratory
Stanton Avenue
Teddington, Middlesex

Project No: NWM006

Report No: 184/99

Date: 21 July 1999

This report is issued as part of the contract between NEL and the client. As such it is governed by the conditions below.

For this report the Client is The National Weights and Measures Laboratory

1 This report may be published in full by the client unless it includes information supplied in confidence by NEL or any third party. Such information, if included within the report, shall be separately designated as confidential by NEL.

2a The prior written consent of NEL shall be obtained by the client before publication by him of any extract from, or abridgement of, this report.

2b The prior written consent of NEL shall be obtained by the client before publication:

- where such publication is made in connection with any public enquiry, legal proceedings or arbitration
- where such publication is made in, or in connection with, any company prospectus or similar document
- where the client has notice that NEL is seeking or intends to seek patent or like protection for any intellectual property produced in the course of rendering the services.

3 These Conditions apply to any third party who should obtain relevant permissions from the Client.

Flow Centre
National Engineering Laboratory
East Kilbride, Glasgow G75 0QU, UK

Tel : +44 (0) 1355 220 222
Fax: +44 (0) 1355 272 536

www.nel.uk

Temperature Compensation of Liquid Fuels

A Study for

National Weights and Measures Laboratory
Stanton Avenue
Teddington, Middlesex

Prepared by: Mr R Paton ……

and Mr D Boam ……

Approved by: Dr B C Millington ……

Date: 21 July 1999
for Dr F C Kinghorn
General Manager

EXECUTIVE SUMMARY

The study was commissioned by NWML in response to concerns over the measurement of fuel delivered to retail outlets. The main focus was the apparent volume losses of product due to temperature changes within the distribution chain.

The study was carried out by contacting some 16 retailers, 56 oil company and supply managers, and around 19 trading standards officers. Opinions were collated in addition to formal submissions from the representative bodies.

Fifteen recommendations have been drawn up and these are listed at the end of the report. The main changes to legislation and practice are summarized below.

To provide good metrology for fuel products, mass is by far the better quantity unit to trade. However, this is technically difficult at present. Correcting volume to a standard temperature is the next best method. This is used throughout the industry for bulk transfers and for duty purposes on fuels. Due to the relatively stable temperatures, high capital expense and labour involved in correction, this concept has not been applied to deliveries of fuel to retailers or final customers. As some delivery temperatures are potentially higher now, and as technology has reduced capital and labour costs, it is the recommendation of this report that Standard Temperature Accounting should be adopted by the industry as a means to improve efficiency and reduce operating costs. Enabling changes to regulation should be brought in to allow this but adoption should be<u>voluntary</u> and based on contract negotiation.

Changes made to health and safety and environmental regulations have caused the primary enforcement mechanism under the Weights and Measures Act to break down. Road tankers can no longer be dipped for volume by either the customer or the Trading Standards Officer. The move to sealed deliveries has to be brought under metrological control to redress this position. As this brings the point of sale to the gantry loading meter, It is recommended that the printing of temperature of fuel loaded to road tankers be mandatory.

Gantry loading metering systems should be brought under metrological control through a system of self-verification using industry standards and codes of practice. Visibility of the verification should be through Trading Standard inspection and audit of the self-verification scheme. Use of accredited calibration teams is also proposed and the infrastructure for this needs to be established.

Other changes to the practices governing the measurement of fuel deliveries have been recommended. Environmental regulation calls for tight stock control in retail tanks. As a result the temperature of deliveries should be available. The industry should consider how to establish and use temperature measurement at point of delivery without affecting the contract position.

The final source of product loss to the retailer is brought about by the introduction of vapour recovery at the loading terminal and the retail tank filling. At the retail end, little change in vapour loss is expected, following the introduction of vapour recovery, over what would have been lost to atmosphere before. At the loading gantry, again no more loss of product is found but due to the change to sealed loads, this loss is not ‘made up’ by added liquid product. An industry initiative should be set up to reduce and quantify these losses and control loading methods and practices. This is not a place for regulation at present.

It must be emphasized that good, open measurement leads to fair, honest and just trade. Poor measurement leads to mistrust, poor contract conditions and increased management costs. It is in the interests of the industry to provide the best measurement practices and control commensurate with the operations taking place.

GLOSSARY

APEA	Association for Petroleum and Explosives Administration
AUKOI	Association of United Kingdom Oil Independents
C&E	HM Customs and Excise
IP	Institute of Petroleum
ISO	International Standards Organization
ITSA	Independent Tank Storage Association
InstTSA	Institute Trading Standards Administration
NEL	National Engineering Laboratory
NWML	National Weights and Measures Laboratory
LACOTS	Local Authority Co-ordinating Body on Food and Trading Standards
OIML	International Organization for Legal Metrology
PRA	Petrol Retailers' Association
UKPIA	United Kingdom Petroleum Industry Association
WELMEC	European Co-operation in Legal Metrology

The fuel temperature definitions given below have been derived for use through the report. These have previously no industry acceptance but were defined to allow expression in a objective way of temperature regions around the standard temperature of 15°C.

Hot fuel	Temperature > 24°C	Approx. 1% volume difference from 15°C
Warm fuel	Temperature > 17°C	Approx. 0.25% volume difference from 15°C
Cool fuel	Temperature < 13°C	Approx. 0.25% volume difference from 15°C
Cold fuel	Temperature < 6°C	Approx. 1% volume difference from 15°C

STA	Standard Temperature Accounting; Accounting for volumes at standard temperature
STV	Standard Temperature Volume; the measured volume corrected to 15°C

C O N T E N T S

FOREWORD

The National Engineering Laboratory (NEL) is an industrial research organization concerned with many areas of mechanical engineering research. Within NEL, the Flow Centre is the holder of the UK National Standards for Flow Measurement. Facilities exist for calibration and research involving water, oil, gas and multiphase flow measurement devices. All the facilities are fully traceable to Primary National Standards and most are accredited by the National Accreditation of Measurement and Sampling (NAMAS). The expertise of the staff associated with these activities allows the provision of consultancy services to the highest levels for industry and government

1 PURPOSE OF THE STUDY

The full specification for the study given by NWML is given in Appendix I. In addition, recognition of the DTI regulatory appraisal guide and the DTI principles of good regulation were requested. NEL offered to carry out this work for NWML and, in accordance with this offer, provides this report as a basis for consultation with industry.

The aims of this consultancy project are to investigate the effect of temperature of product on the measurement of liquid fuels (petrol and diesel), and to recommend any regulatory changes that might be justified in the light of technical and commercial considerations.

2 CONDUCT OF THE STUDY

The study was carried out over a period of 4 months by correspondence and telephone contact. Initially all interested representative bodies were contacted and asked for contact names who could assist. The study itself was publicized in the IP Petroleum review, the Bulletin of APEA, NEL Flow Tidings and on the NEL website. LACOTS also circulated details to its representatives.

To investigate practices in other countries, legal metrology organizations within WELMEC were contacted along with authorities in Canada, Australia and USA.

In the original plan for the project, measurements of delivery temperatures at three or four locations were considered. During the initial information gathering, it was became very clear that such a limited amount of measurement would be unrepresentative. The geographic, and time variations in both ambient and delivery temperature vary considerably from depot to depot, time of day, and place of delivery. Any measurement programme would have to cover hundreds of measurements taken over considerable time and geographic spread. It was considered better to drop the requirement for such a limited sampling exercise and redirect the effort into better information gathering hence avoiding any incorrect conclusions from an unrepresentative sample. It was also planned to visit gantry loading depots. Again the information coming in from the contributors was adequate to understand the process of loading and, unless access to a depot where perceived problems existed could be arranged, it would be unrepresentative to carry out a visit. Such a visit proved to be difficult to arrange and hence the depot visit was not carried out.

A forecourt delivery was observed.
The draft report was posted on the NEL website and this has proved a popular and efficient method of dissemination of the draft. The accessibility and the reduction in administration in preparing and distributing copies have more than justified this approach.

Following the issue of the draft report, a seminar was held at NWML on 11 March 1999 at NWML Teddington. Comments from attendees have been addressed. Subsequent to the seminar a number of written and telephone comments were received and these have all been recognized in the preparation of the final report.

Following the issue of this report the procedures for dissemination, public consultation and legislative changes will be carried out by NWML.

3 MECHANISMS FOR STOCK LOSS

In discussing the issue of stock loss it is important to understand the physical processes undergone by the fuel between the gantry meter at the depot and the dispensing pump at the retail outlet. It is also important to distinguish between two types of stock loss, true and apparent. A true stock loss is defined here as one involving a loss of mass while an apparent loss involves only a loss of volume and not an escape of mass from the delivery chain. By reducing the volume available for resale apparent, or volume-only, losses are, of course, as real in financial terms to the stockholder as true, or mass, losses.

Liquid hydrocarbon fuels, whether petrol or diesel, are complicated mixtures of many individual hydrocarbons. These mixtures vary by source and by time of year. This makes an analysis of mechanisms such as evaporation very complex and, when combined with the wide variety of heat and mass transfer processes involved in the fuel distribution chain, puts a detailed quantification of stock losses beyond the scope of this study. However the types of loss and the underlying mechanisms are discussed briefly below.

3.1 Apparent Losses

Apparent losses can arise from two sources, errors in the metering chain and changes in density of the fuel.

3.1.1 Errors in the metering chain

It is a fundamental principle of metrology that any measurement, no matter how accurate, is only an estimation of the true value of the quantity being measured and this applies as much to the measurement of liquid hydrocarbons as to any other measurement. All other factors being equal the amount of fuel dispensed is an absolute quantity the size of which is ‘estimated’ in turn by the gantry meter, the retail tank gauge and the retail dispensing pump. Apparent losses can therefore arise if the gantry meter overestimates or if the tank gauges or dispensing pumps underestimate the volume. The size of any discrepancies will vary with calibration accuracy, calibration frequency and the closeness of the calibration flow conditions to the real life conditions. Retail dispensers are very closely monitored by Trading Standards officers for compliance within a permitted error band but the level of apparent loss will depend where in that band the dispensers are set.

Errors in the metering chain will affect diesel and petrol equally.

3.1.2 Shrinkage

All substances whether gases, liquids or solids expand and contract with temperature and liquid hydrocarbon fuels are no exception. Different liquids have different expansion coefficients and those of liquid fuels reflect the complex mixtures that make up the fuels.

Typically, in the region of ambient temperatures, petrols will expand or contract by 0.12% volume for each ºC change in temperature while diesel fuels will change somewhat less, 0.08% volume/ºC. Thus relatively small changes in temperature will result in significant changes in volume; 2ºC will result in 0.25% volume change for a typical petrol and 8ºC will result in a 1% change, while the same temperature changes will affect diesel volumes by 0.16% and 0.6% respectively.

3.2 True Losses

True losses can result from a number of mechanisms namely:

incomplete emptying,
spillage,
theft,
leakage,
vapour loss on transfer, and
breathing losses from storage tanks.

3.2.1 Incomplete emptying

Increasingly normal practice is to make deliveries to filling stations on a basis of whole compartment loads. At the same time the introduction of sealed vapour recovery systems and of Health and Safety regulations governing access to the top of tankers makes it increasingly difficult for retailers to verify, by dipping, that the compartment is, in fact, empty and that the full load has been delivered. Any fuel retained in the compartment would appear as a loss to the current retailer but would result in the compartment containing excess fuel when refilled and so would appear as a gain to the next retailer. On balance, therefore, the effect should cancel out. Percentage losses by this mechanism would apply equally to petrol and diesel deliveries.

This mechanism does not apply to deliveries still made on a part-consignment basis to small retailers as in these cases the amount delivered should still be determined by dipping the tanker.

3.2.2 Spillage

Spillages during transfer are difficult to quantify but, with good practice, should be rare events involving only small quantities of fuel. Percentage losses by spillage should be similar for both petrol and diesel.

3.2.3 Theft

The deliberate removal of stock from a road tanker by an unscrupulous driver or from retail storage tanks by dishonest filling station employees is beyond the scope of this study but should be identifiable through proper seal verification and other security measures.

Losses of petrol and diesel by theft should be very small and should be similar in percentage terms.

3.2.4 Leakage

Leakage of fuel from storage represents a serious environmental hazard and careful stock monitoring is needed to ensure the rapid detection of significant leaks. As leaks can only

be detected by losses in volume they can be masked by other factors, such as thermal expansion, and so go undetected, or time and money can be wasted searching for phantom leaks that are the result of other volume changes.

3.2.5 Vapour loss on transfer

Vapour losses on transfer arise from two sources, loss of vapour in the ullage space and outgassing of volatile components during the transfer.

Vapour loss from the ullage spacearises when the mixture of air and fuel in the ullage space in any tank is displaced by the incoming liquid fuel. Subsequently, as fuel is used, fresh air is drawn into the tank to replace the volume of fuel withdrawn. Fuel then evaporates from the bulk liquid in the tank until the air in the ullage space reaches saturation. The mechanism occurs when fuel is put into terminal storage and dispensed to the tanker, when fuel is put into the tanker and discharged to the retail tanks, when it is loaded into the retail tanks and dispensed to the motorist, and finally when the vehicle tank is filled and fuel pumped to the engine. Past practice was for the air/vapour mixture to be expelled to the atmosphere via the tank vent and the fuel was therefore lost to the environment. With modern petrol engine burning about 98% of the fuel entering the cylinders and with catalytic converters burning about 75% of unburnt fuel leaving the engine, total emissions from the engine exhaust represent only about 0.5% of fuel usage. Vapour losses from ullage spaces are likely to be of the order of 0.15-0.2% at each of the stages listed above and the fuel supply chain emissions are therefore comparable with vehicle operating emissions. This has led to the progressive introduction of vapour recovery technology starting at the refinery end of the supply chain.

Current, vapour recovery, practice at the retail filling station is to draw the air/vapour mixture into the ullage space on the tanker to avoid the discharge to the environment. As a result the retailer should incur a similar loss as previously and the fuel supplier is left to dispose of the vapour in a less harmful way. The methods of disposal permitted depend on the size of the depot with some sites being allowed to flare the mixture, to release carbon dioxide and water vapour instead of more damaging hydrocarbons, while others are required to recover the vapour back to the refinery process.

The amount of fuel lost as ullage space vapour depends on the vapour pressure of the fuel. Losses of diesel will be insignificant due to the very low vapour pressure; losses of petrol will depend on the temperature of the ullage space and on the volatility of the fuel, which varies with the season of the year to meet the conflicting requirements for cold starting and vapour lock in the vehicle fuel system.

Outgassing of volatile components As already mentioned, liquid hydrocarbon fuels are complex mixtures of many components. In the case of petrol these components will include volatile components such as butane and pentane. These components, included to satisfy vehicle cold starting requirements, will evaporate readily and may even come out of solution to form vapour bubbles in the transfer pipes as pressure in the liquid falls below the effective vapour pressure. Pressure drops will occur whenever a liquid flows; pressures in the filling pipe are therefore lower than in the supply tank. Any bubbles formed will recondense when the liquid pressure rises again as it comes to rest in the storage tank. If, however, they are able to rise to the surface before recondensing they will be released as vapour to the ullage space and expelled with the normal ullage air/vapour mixture as already discussed.

The outgassing process results in the air/vapour mixture expelled from the tanks being super-saturated with vapour and as a result condensation will occur. This can happen in two ways, a fog can form in the air stream and fine droplets will then move with the air into the tanker or out to atmosphere, or droplets of condensate can form on the pipe walls. In the case of a fixed vent stack condensation forming on the pipe walls will ultimately drain back into the tank or evaporate into the air drawn into the tank during retail dispensing. In the case of a tanker vapour recovery system it is reported that the normal practice is to elevate the lines at the end of the filling process to drain any condensate back into the retail tanks. The extent of any condensation process will depend on the temperature of the pipe walls relative to the saturation temperature of the air/vapour mixture.

As outgassing is a volatility phenomenon it will only occur with petrol and is strongly dependent on the temperature, which controls the vapour pressure. The potential for outgassing has always existed but it increases with liquid velocity in the transfer pipes. Changes in practice with the introduction of vapour recovery systems may therefore have an influence as vapour recovery lines to tankers are generally larger than tank vent lines and so present less resistance to flow of vapour, reducing static pressure and hence potentially increasing vapour concentration. Seasonal changes in volatility will also impact on the occurrence of this loss mechanism. Where liquid is stored under pressure it has the potential to hold higher concentrations of volatile components in solution and so will have a higher vapour pressure. Such fuel would be more prone to outgassing problems.

3.2.6 Breathing losses from storage tanks

In normal operation the vent pipe on a tank will serve only to admit air to replace the volume of liquid dispensed to the motorist. However, under some conditions, the gas in the ullage space may expand and some will be expelled through the vent and released to atmosphere. The principal cause of this will be a reduction in atmospheric pressure when ullage gas will be vented to equalize the pressures in the tank and at the vent. The expelled gas will take with it a proportion of the vapour in the tank. This vapour will disperse and, when the atmospheric pressure rises again, pure air will be drawn into the tank allowing additional evaporation from the bulk liquid.

Wind blowing across the vent pipe will also generate a low pressure at the vent, creating a mechanism similar to atmospheric pressure changes with vapour being lost when the wind blows and air drawn in when the wind drops. Changes in temperature will create the same effect as the ullage gases expand and contract.

These breathing losses can therefore be seen to be dependent on the site exposure, but at most sites are likely to be substantially less than the vapour losses incurred in tank filling. Being vapour losses, they occur only with petrol and are dependent on the storage temperature.

3.3 Thermal Processes Affecting Fuel Storage and Transportation

Of the loss mechanisms discussed above, those relating to evaporation or to contraction are highly dependent on fuel temperature and it is therefore instructive to look briefly at the heat transfer mechanisms controlling fuel temperature between the gantry meter and the forecourt dispensing pump.

3.3.1 Loading into the tanker

Flowrates in the filling pipes are quite high and there will be vigorous forced convection between the fuel and the pipe. However the controlling mechanism will be the heat loss from the outside of the pipe, where weak natural convection will dominate. As a result the pipe wall temperature will be very close to the liquid temperature and almost no heat will be lost from the fuel. On arrival in the tank the fuel and the tank walls come to an equilibrium temperature. However, since the thermal inertia of the fuel is far greater than that of the tank, the effect on the fuel temperature is small. After loading the fuel is therefore still very close to the metering temperature.

3.3.2 Transport to the retail filling station

The principal heat transfer mechanisms affecting the fuel during the journey to the retail forecourt are radiation and forced convection.

Radiation has two effects on fuel temperature during transport. At night heat will be radiated from the fuel to the night sky and, if the tanker is left parked having been loaded in the evening for a morning delivery, the fuel could cool significantly. This would show as a loss of volume between loading and delivery. During the day solar radiation to the tanker during its journey will warm the fuel causing an increase in volume and an apparent over-delivery.

As the tanker travels from depot to the forecourt, the air-stream around the tanker will transfer heat to or from the fuel. The heat transferred will depend on the relative temperatures of the fuel and air but, since depot tank temperatures will be relatively stable at a mean temperature, fuel delivered on a warm afternoon will generally be heated by the air while that delivered overnight will be cooled. The extent of any convective heating or cooling will depend on the air stream and on the exposed surface area of the tank, effects are therefore likely to be greater for the front compartment of a tanker than for a central compartment.

The heat transfer mechanisms affecting the fuel in the tanker are outside the control of the supplier but may lead to temperature changes of several degrees. As a result, controlling fuel temperature at the gantry is no guarantee of a fixed temperature on delivery.

3.3.3 Loading into the underground tank

This process is similar in heat transfer terms to the process of loading into the tanker with poor heat transfer outside the pipe preventing any significant heat losses from the fuel.

3.3.4 Forecourt storage

Once the fuel is in the storage tank the heat transfer mechanisms vary depending on the tank location; above-ground tanks will be affected by radiation and convection whilst underground tanks will be affected mainly by conduction, with convection and radiation only playing a part in affecting ground temperatures.

The principal effect on above-ground storage will be the effect of wind and therefore of site exposure. Contraction losses may be experienced on exposed sites.

The thermal behaviour of underground tanks is complex but in essence will depend on the difference in temperature between the tank and the soil around it. Underground temperatures vary with season and depth. Surface fluctuations over the year are typically damped out completely at a depth of 15 metres; at the normal depth of storage tanks the fluctuations are about 70% of those at the surface. In addition the thermal inertia of the soil has the effect of introducing a progressive time delay with depth, and at tank depths the temperature wave can typically lag the surface wave by 2-3 months. This lag means that volatile autumn and winter grade fuels can potentially be stored in soil that is warmer than the surface temperature, which would result in increased vapour losses; conversely, spring and summer grade fuels could be stored below surface ambient temperatures and so experience greater contraction losses. The extent of the damping and time lag will depend on the thermal conductivity of the soil and also on its thermal capacity. Both factors will depend on the 'soil' type - sand, clay, pea gravel, concrete, moisture content and tank design. These free-field temperature regimes will be distorted by the introduction of large volumes of fuel into the tank and a detailed analysis of the effects is beyond the scope of this study.

Another important factor in determining the thermal behaviour of underground tanks will be the surface temperature, which controls the amplitude of the seasonal fluctuation at depth. Here site exposure to winds, site orientation, frost hollow effects due to slopes above the site, forecourt paving (dark asphalt or light concrete) and the presence of canopies over the tank area, screening out solar radiation gains and reducing night radiation losses, will all play a part.

As the rates of heat transfer to and from the fuel are low compared with its thermal inertia, time is also a crucial factor in determining the storage temperature. As a result, low turnover rural sites are likely to see greater changes in temperature than high turnover motorway or urban sites.

Because of the interaction of site exposure and soil conditions, contraction losses can be very site specific and fuel delivered within the same tanker load to two different sites may exhibit different evaporation and contraction/expansion losses. Regulation and control of gantry temperatures could therefore affect the apparent stock losses of different sites in different ways.

3.3.5 Delivery to the dispensing nozzle

Pipes taking fuel from forecourt storage tanks to the retail dispensing nozzles will typically be buried about 0.3-0.5 m below the surface, may have a double wall, and for protection will normally be encased in concrete. At this level seasonal temperature fluctuations will be almost the same as at the surface and the lagtime will also be short; in contrast, daily fluctuations will be almost completely damped out at this depth. As a result ground temperatures around the pipes will be close to the monthly average ambient temperature.

Fuel left to stand in these pipes will, with time, come to the ground temperature. The volume of these pipes is such that on sites with a high proportion of small volume sales and with significant intervals between sales the effect will be that fuel is sold at a temperature close to the seasonal average temperature. On busy sites with a high proportion of complete-vehicle-tank sales, fuel will be drawn from the storage tanks and dispensed direct to the motorist and, although some heat transfer will take place between the flowing fuel and the ground, fuel will be dispensed at a temperature closer to that of the storage tank.

3.4 Reported Stock Losses

As stated above, a detailed quantification of the losses ensuing from the physical processes described in Sections 3.1-3.3 was considered to be beyond the scope of this study and instead the magnitude of the losses can be gauged by the stock losses reported by individual retailers through PRA. No information was supplied by non PRA sources.

3.4.1 Overall losses

Figs 1 and 2 show the results of a limited survey conducted by PRA and reported in their submissions both to NWML before the commencement of this study and as an attachment to their formal response within this study. Loss data were supplied by some 67 retailers covering both motorway and non-motorway sites. It is not known what range of sites, eg urban, suburban, supermarket or rural, was included under the heading of non-motorway sites. The data are derived from a balance of delivery records, tank gauges and retail dispenser logs.

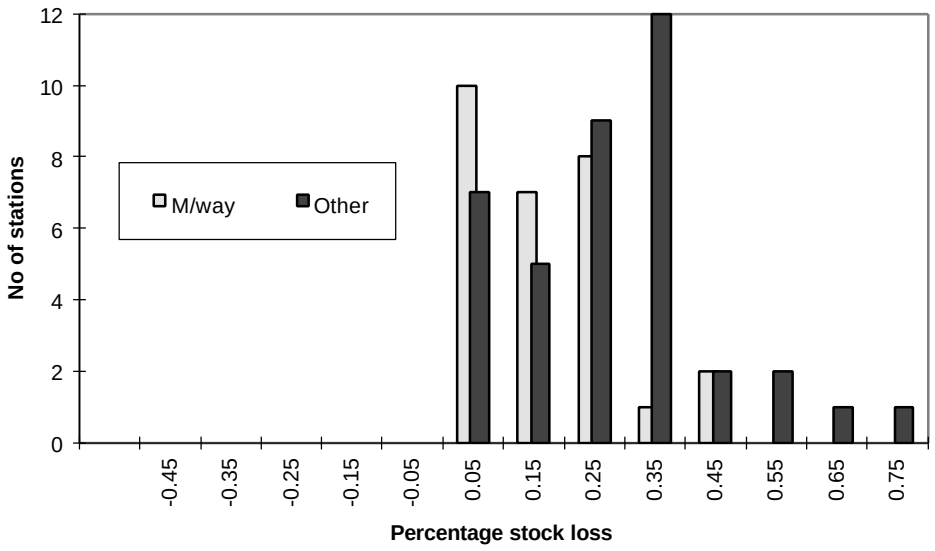

Fig 1 PRA Survey of Petrol Stock Losses

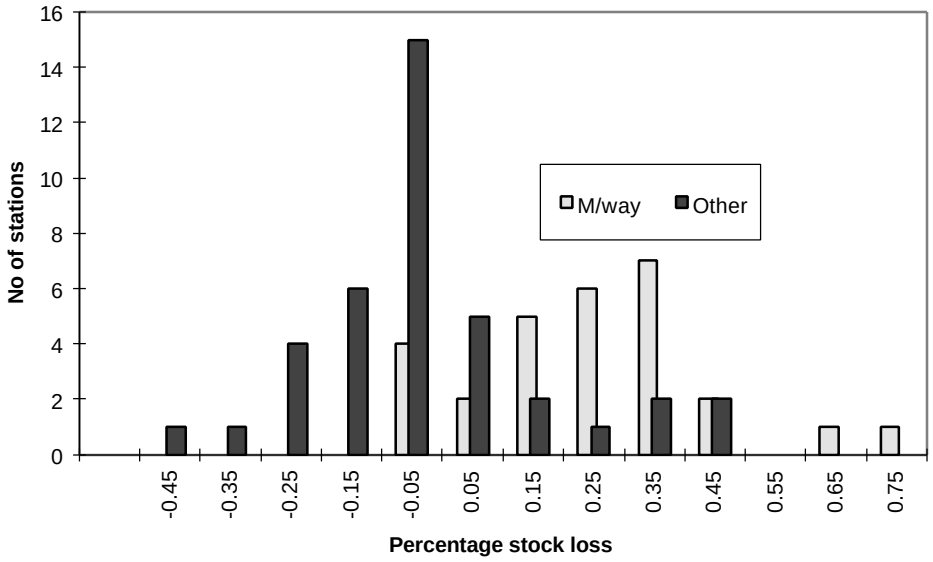

Fig 2 PRA Survey of Diesel Stock Losses

A number of conclusions can be drawn from the data of Figs 1 and 2. Looking first at the petrol losses on Fig 1, it can be seen that there are clear differences between motorway and non-motorway sites with substantially smaller losses on motorway sites. This probably reflects the high turnover and short storage times on these sites and may indicate that fuel is not reaching thermal equilibrium in storage.

The diesel data on Fig 2 also show a difference between motorway and other types of site, though in this case motorway sites show larger losses. Reasons for this are not obvious but may relate to differences in the sales profile and throughput of diesel between different site types, with motorway sites having a higher proportion of retail sales of diesel as a consequence of HGV refuelling.

Both Figs 1 and 2 show a wide spread of losses with a range of 0.75 to 1%. As might have been expected from the relative volatilities of the two fuels petrol (Fig 1) shows a significantly greater loss than diesel. What is harder to understand from Figs 1 and 2 is why the diesel data show a normal type of distribution about the mean while the petrol data are heavily skewed with a sharp cut-off at zero loss and no stations reporting even small gains. If the sole difference between the two fuels was that of volatility the normal distribution patterns seen with diesel should simply be shifted to the right for petrol by an amount equal to the vapour losses.

3.4.2 Losses by terminal type

In a further survey PRA collected stock loss data from a wide range of retailers and collated them by delivery terminal. In their submissions PRA presented data from selected terminals and these are shown in Fig 3. This confirms the greater losses experienced with petrol than with diesel and also indicates that losses on all fuels are greater from refinery-based deliveries than from pipe- or sea-fed terminals, although there is considerable scatter in the data.

In addition to the survey data supplied by PRA, evidence of stock losses was supplied by individual retailers. Again this took the form of a reconciliation of deliveries, tank gauges and retail dispenser logs. Evidence of different levels of loss from different terminal types is shown in Figs 4-7. In Fig 4 the losses from one site over successive years, during which supplies were switched from a pipe-fed terminal to a refinery terminal, are shown and support the view that losses are greater when supplies came direct from the refinery.

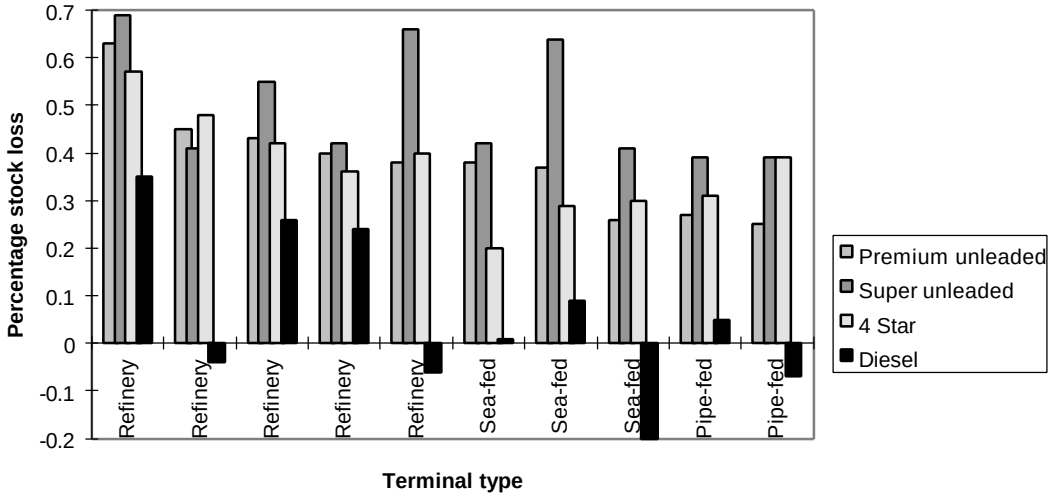

Fig 3 PRA reported stock losses by terminal type

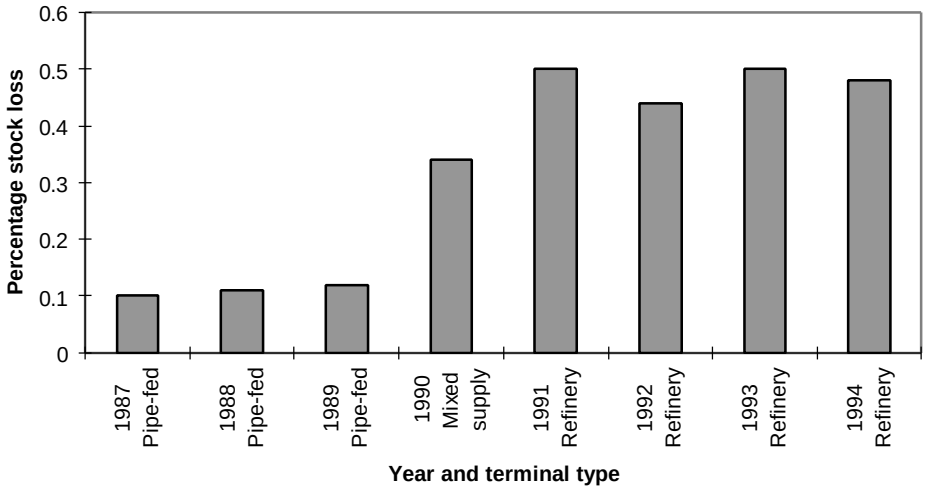

Fig 4 Reported petrol stock losses for single site showing effect of change of terminal type

Fig 5 shows daily stock losses from a single underground tank over a 13-week period and illustrates the problems of interpreting stock reconciliation data. However, when the data analysis techniques of BS 5703 are applied a clear trend emerges (Fig 6). Here a rising trend indicates losses below the average for the whole period, while a falling trend indicates above-average losses. Fig 6 shows a sharp change in the loss rate at about the end of week 6 when the fuel deliveries were switched from a pipe-fed terminal to a refinery

terminal. Fig 6 also shows data from two other tanks of the same, unleaded, fuel delivered to a second site over the same period. The refinery supplying the fuel from the end of week 6 was also the one that had previously fed the pipeline so the actual fuel source, and therefore, presumably, since the period did not involve a change in fuel volatility grade the fuel remained unaltered.

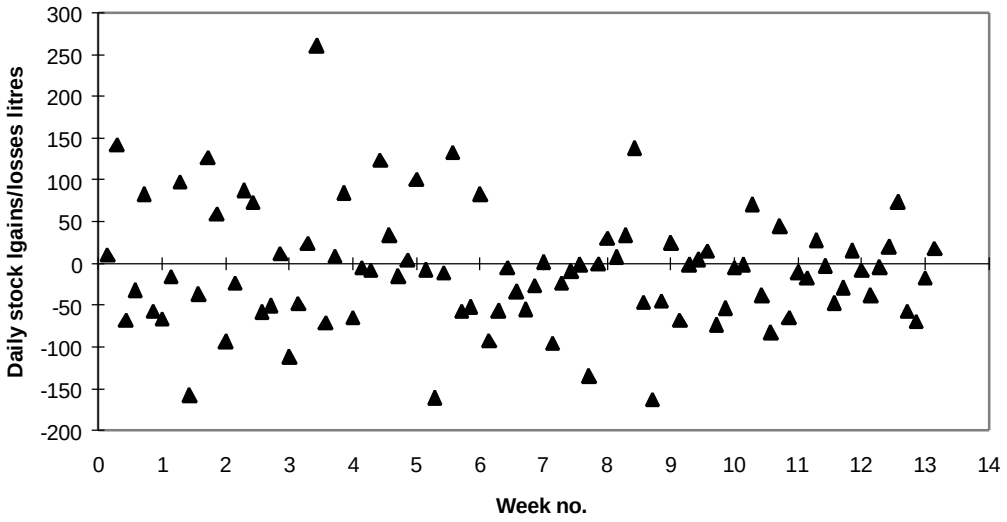

Fig 5 Daily stock losses of unleaded petrol over a 13-week period from a single underground tank

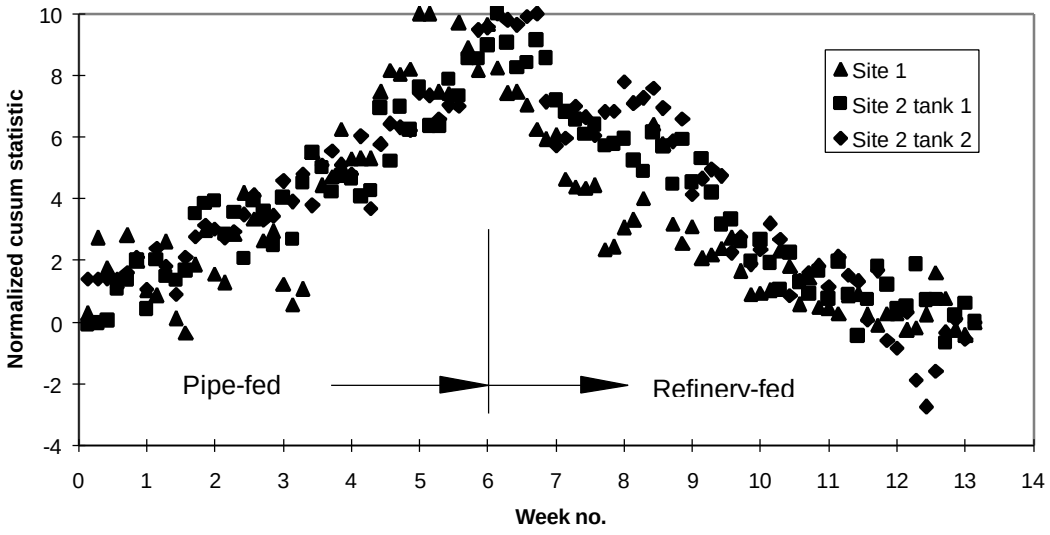

Fig 6 Analysis of daily stock losses,using cusum technique of BS 5703, for three unleaded petrol tanks

Further evidence of the differences in losses when fuel is supplied from different terminals came be seen in Fig 7, which shows data from a small chain of retail outlets in which 5 sites are supplied from a single refinery terminal, 5 are supplied from a single pipe-fed terminal and 3 from a single sea-fed terminal. Again greater losses are seen when supplies are obtained directly from a refinery rather than from a pipe-fed or sea-fed terminal.

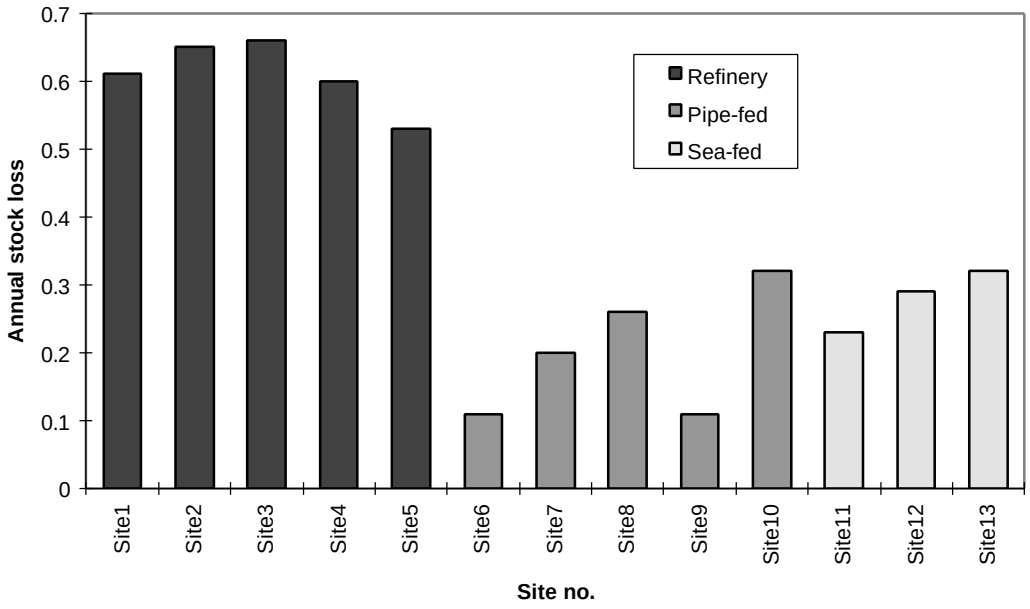

Fig 7 Annual petrol stock losses from a retail chain suplied from 3 terminals

3.4.3 Loss variations between sites

In Section 3.3 it was suggested that, because of differing site conditions, losses could be different on different sites even when they were supplied by the same terminal. The data of Fig 7 back this up as different sites within the retail chain show very different annual stock losses. This is reinforced by Fig 8 where data are shown from 10 sites in another chain, all supplied from the same refinery terminal. Fig 8 shows that losses can vary by a factor of three between sites.

Fig 8 also shows differences between 4-star and unleaded losses at each site in the chain but with no consistent trend between the fuels. While the inter-site variation may, in part, reflect variations in site layout and soil conditions, the inter-fuel variations are more likely to reflect errors in instrumentation.

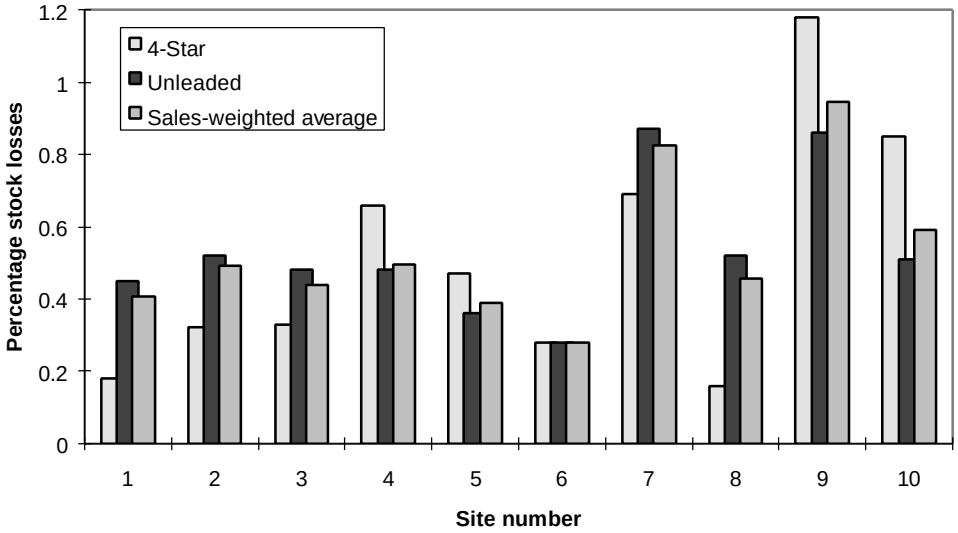

Fig 8 Variation of stock losses across one retail chain (all sites supplied by common refinery terminal)

3.4.4 Seasonal variation in stock losses

As stock losses, whether by evaporation or by contraction, are dependent on fuel temperature it might be expected that losses would be seasonal in nature. Fig 9 shows monthly loss data for one year from 4 sites in the same retail chain and supplied from the same refinery terminal. No clear trend emerges from Fig 9 with large variations between sites for any individual month and no one site having consistent larger or smaller losses than the others. When the average across all the sites is plotted (Fig 10) a trend begins to emerge with monthly losses following the trend in local monthly average temperatures. However, there are still anomalies in data for some months (eg January and October) and the uncertainty bands derived from the inter-site variations are sufficiently wide to make any trend difficult to isolate. The temperature data are the average for a 10-year period while the losses are for one year and it would be preferable to have a much larger data set before drawing any conclusions about seasonal trends.

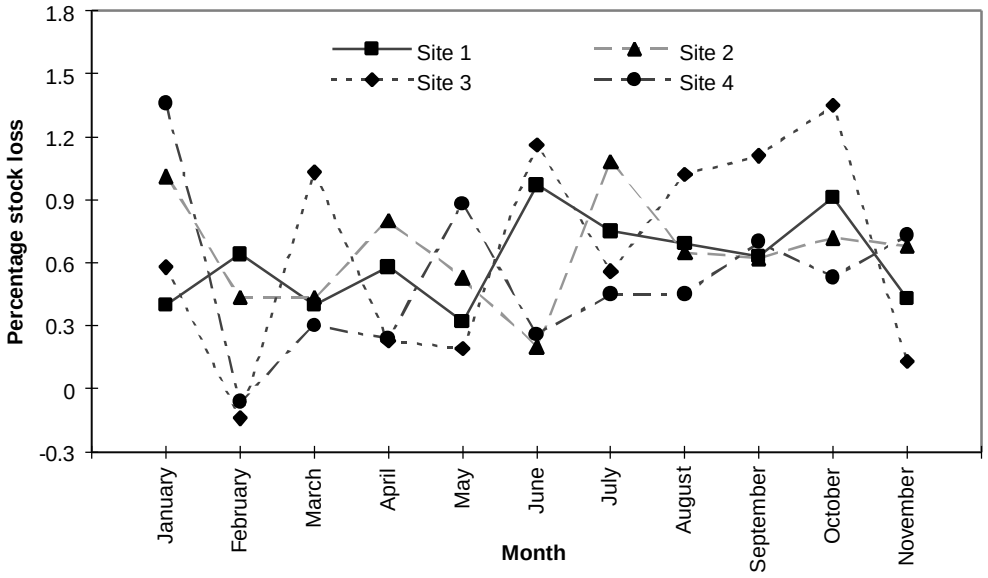

Fig 9 Variation of stock loss with season for 4 sites in the same retail chain and supplied from the same refinery depot

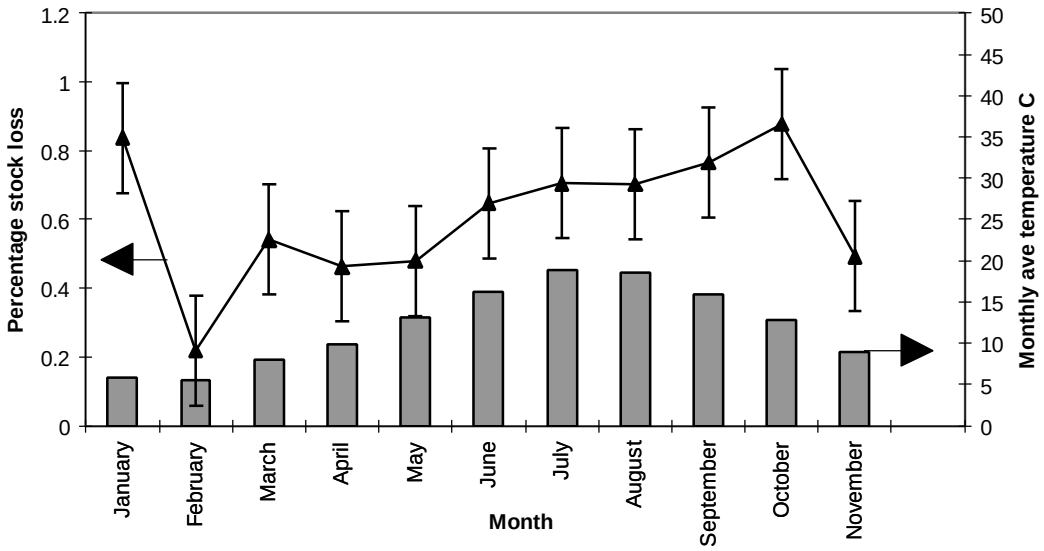

Fig 10 Average monthly stock losses across four sites (derived from the data of Fig 9)

3.4.5 Summary of reported stock losses

The PRA and its individual members presented a substantial body of data to illustrate the levels of loss experienced by retail site operators. These data showed clear differences between diesel and petrol and between fuel supplied from refinery terminals and those at the end of longer supply lines. The data also showed large variations between sites. Seasonal trends were harder to identify as there were wide variations within a relatively small set of data.

4 SUMMARY OF DISCUSSIONS

This section provides an interpretation and distillation of the findings from contacts with each industry sector. Contacts were made through names provided by the organizations involved, by advertising the survey in trade journals, and with appropriate contacts from NEL sources. In each section below the replies and conversations have been summarized and the salient points highlighted. Little attempt has been made to comment on the opinions expressed unless this was considered advantageous to clarify the points.

4.1 Retailers

Retailers have provided the group who believe the present situation generally disadvantages them. Formal contributions were made from a number of independent retailers and discussions with many more. Three classifications of retailers were considered. Small independent retailers, large chain independent retailers and company owned or agent retailers. The third category was not surveyed formally and informal contacts indicated that, although there was an acceptance that reconciliation of delivered volumes was difficult due to temperature differences, they were not at liberty to discuss the issue or provide measurement sites without company approval.

4.1.1 Small independent retailers

This category of retailers provided the data and opinions that show that serious concerns exist over the reconciliation of volume deliveries. Concerns were expressed and have become more vocal against a background of decreasing profit margins from sales and increasing accountability of stock for environmental control. Not surprisingly none reported deliveries of cold fuel allowing extra fuel to be dispensed.

The data provided by retailers (Section 3.4) show clearly that warm fuel deliveries are common. The delivery of hot fuel occurs and is well documented but the extent of this is less certain. It is clear that fuel is delivered warm to retailers in sufficient quantities to give rise to an accountancy problem that reduces profit margins unless dealt with. For some retailers this is recognized by the provision of a supplier ‘warm fuel allowance’. This reduces the price of fuel to the retailer when fuel comes from certain depots. No access to the technical or commercial justification for these allowances was available to the survey.

The potential loss of revenue to the retailer comes from the delivery of fuel that subsequently reduces in volume before sale. The retail price recovered by the retailer consists of four factors: the price of the fuel, the petroleum excise tax, VAT and the profit margin. Taking the first three in turn.

If the retailer receives warm fuel that cools before being dispensed, he can sell less fuel than he purchased.

The retailer also pays petroleum revenue tax to the supplier based on the delivered volume, which again is lost through fuel shrinkage. It was pointed out that this payment is not credited to the Treasury as Customs & Excise (C&E) collects the tax based on STV. Some suppliers may operate STA on this component.

The third payment is for VAT, which is recovered on the quantity sold but is payable to C&E based on the volume delivered to the retailer. Discrepancies in volume due to shrinkage attract VAT payments to C&E. C&E pointed out that the VAT inspector has powers to recognize legitimate stock losses and apply dispensation for payments.

At this point no mention was made of the reverse situation where cool or cold fuel may allow the retailer to sell a greater volume than they receive when fuel expands in retail storage. However, the PRA survey of retailer stock losses shows that this situation arises regularly with diesel fuel (Fig 2).

No opinions were expressed regarding the use of STV at the dispenser other than the equipment costs. Most retailers recognized the logic of the concept and were neutral on implementation of the idea.

Lack of widespread, accurate information on the temperature of delivered product and the poor quality of data from retail instrumentation mask the full extent of the delivery problem but it is the small remote independent retailer, served from certain refinery-based depots, and with small throughputs who seems consistently to lose out on delivery volumes. It is this class of retailer who will find it difficult to negotiate contract allowances and VAT reductions.

4.1.2 Large independent retailers

This class of retailer encompasses the supermarkets and chain retailers with up to 400 stations. This group is affected by the same parameters as the small retailers. However, they have one major difference: they operate in a very different commercial environment. Large value contracts can be negotiated with suppliers and contract prices can factor in potential losses and gains due to temperature variations. The high contract values and infrastructure available allow monitoring of geographic and seasonal variations and, of course, the ability to provide expert examination of oil supplier practices and methods. This can result in contract conditions that reflect the commercial realities of apparent and real stock losses.

TSOs reported a number of investigations initiated by large retailers concerned over stock losses.

In general the large independent retailers are fairly neutral on the requirements for STA. Advantages are seen in reducing risk on contract negotiation, and recognizing stock loss concerns, while any potential cost increase in fuel price due to the application of the mechanics of introduction is seen as a disadvantage.

Some independent retail chains were concerned about the lack of control of the delivery metering in depots and could cite numerous cases of consistent under-deliveries from certain depots and of how witness visits assisted depots to improve delivery practice. No indication was given of over-deliveries arising from problems with delivery metering.

4.1.3 Representative bodies

Both the PRA and AUKOI were requested to respond formally.

The PRA represents the interests of the independent retailers and their extensive correspondence spanning many years was considered. They put a strong case for accounting for fuel at 'ambient' temperature. This has been considered in this study but is difficult to support. Other submissions by the PRA show a determination among retailers that something is wrong with the current system of accounting and measurement and this is not being addressed within the industry.

AUKOI represents both retail and supply interests but replied with the retail interests mainly in mind. AUKOI was apparently content with existing arrangements as market forces can be used to resolve most of the financial losses. They would be happy to adopt STA provided that it did not add to costs within the industry without a clear benefit.

4.1.4 Additional Comment

The concern noted by NEL in working with the retailers was the high degree of suspicion engendered by discussions with their suppliers. This has made it difficult to separate true measurement needs from biased reporting. There is a deeply held and widespread belief within the retail community that they are being 'short changed' over deliveries. This continues through to many retailers who honestly believe that they are being seriously overcharged for product and that a serious and widespread measurement fraud is involved. It is difficult to believe that such a situation of consistent under-delivery benefits the supplier in the longer term but the perception is certainly not healthy within the industry and must be incurring disproportionate management costs. It was also clear that the market freedom expressed so often is difficult to implement due to restrictions in pricing suggested by suppliers and the penalties in moving from a supplier during the contract period.

4.2 Oil Suppliers

Oil suppliers were approached directly, some via more than one route. Contact was made via UKPIA, who provided names and contacts, and also in some cases by direct contact through known and speculative routes. Attempts were made to obtain opinions from depot managers, company retail managers and managers in charge of oil loss control. A formal approach was made to depot managers via the UKPIA supplied contacts to survey current practice and temperature conditions.

4.2.1 Oil companies

Oil companies were contacted both formally and informally. The informal contacts were helpful, and there was good co-operation on a technical level in explaining practice and custom. This help was appreciated. On the formal level, however, responses were not quite as helpful. It is the stated belief of oil companies that no significant problem exists that requires temperature compensation on fuel deliveries. The topic of fuel pricing is a contractual one between supplier and retailer and normal contractual negotiation should be carried out to resolve any differences due to apparent stock losses. The contract between supplier and retailer is not fixed and an independent retailer is free to move to another supplier at any time. The costs of this move were not discussed, nor were they of interest to this study. All stated that information on temperature of fuel deliveries from depots was confidential. Some provided information on this basis.

Overall, temperature fluctuations in fuel deliveries are considered to balance out across the country and the year, and average around 15ºC. No supplier considers that STA would provide an advantage to the industry in terms of contracted delivery of fuel, although oil loss control could benefit. The high capital costs of installing temperature measurement and billing arrangements would increase the price of petrol and reduce retailer margins even further. Most depots now measure temperature and the rest will follow shortly. Temperature compensated volumes are calculated on many sites for C&E or oil loss purposes. Recognition is given to the possibility of some local occurrences of high delivery temperatures but these are not considered significant and are commercially sensitive.

It is stated that, in general, companies consider they under-recover petroleum tax since they believe the average delivery temperature is a bit below 15°C.

Some companies declined to contribute to the survey of depots on the grounds that the information was commercially sensitive. One company provided only the average temperature of all products from all depots across the year, which was less than useful. No data from owned retail outlet studies was offered.

In all 44 replies and direct contacts were made through written or verbal communications.

4.2.2 Independent oil storage companies

The organizations were helpful, but as they do not own the fuel received or delivered they were formally neutral on the subject of compensated deliveries. They recognized the technical advantages to stock accounting. The application of compensation to deliveries was of course a contractual matter between the owner of the fuel and the retailer. Twelve contacts were made with independent oil suppliers.

4.3 Trading Standards

In all some 19 Trading Standards officers representing 15 local areas across the UK were contacted. Overall they saw their responsibilities split into two distinct functions.

Firstly the Trading Standards function has to be covered.

Views varied from expressing little interest as the complaint level was low through to an opinion that a major under-delivery situation existed across the country, which could be interpreted as fraud. It is obvious that TSOs will see a biased view of the situation as retailers being delivered cold fuel, and hence gaining stock, do not contact Trading Standards to complain.

The general view points to a belief among TSOs that there probably exists an unfair measurement of delivery of significant proportions. They expressed a frustration that they had not the technical, legal or skill level to investigate fully the extent of the problem, or that the extent of the problem was not being fully reported. They were unable to determine factually if a major problem existed, or if it was compensated by an equally sized over-delivery in which they had no interest. They felt that the problem was real and that some retailers were being significantly disadvantaged by delivery of warm or even hot product. They pointed out that their job was being made extremely difficult by the restrictions in access to tanker dips. Enforcement and checking of delivered quantity was no longer possible, hence opening the door to malpractice.

The second function, as petroleum officers, is the enforcement of the environmental regulations

This function was taking a higher priority than that of Trading Standards work. The reporting of stock losses or gains that vary from the normal operating pattern was mandatory but very difficult to verify. Quoted examples of stock losses on a daily basis starting high and reducing with time were common, and involved lengthy investigations to show that no leakage was responsible. In most cases no reliable data was available to judge or estimate temperature shrinkage effects.

Generally TSOs expressed concern about the nature of the measurements in the industry, the quality of forecourt instrumentation and its maintenance, and the amount of secrecy involved in obtaining information. They were very concerned that they were increasingly being unable to carry out their function. The general opinion was that, because of the spread of complaints, the time span of the complaints and the difficulty in investigation, more transparency is needed in the system.

Opinions on policing any transactions varied from the pro-active to the re-active. It was accepted that the skill level of TSO to carry out verification of gantry systems was not in place. It was also stressed that the relevant equipment and expertise could not be put in place without serious technical difficulties. For financial reasons this would not be carried out by every authority. It was suggested that regional equipment be provided and used as required in any area. The concept of using contractors was treated with caution. Self verification was discussed but it appeared that the TSO role in a self verification scheme had not been considered in detail with regard to informing, witnessing, or otherwise inspecting procedures. Accreditation of TSO verification service was not discussed.

The degree of interest and awareness in the topic was very high and from this it must be assumed it is seen as an important area of responsibility.

LACOTS and InstTSA were asked to prepare formal responses.

4.4 Practice in Other Countries

As part of the investigation, various other countries, particularly within Europe, were contacted for their current practice.

The members of WELMEC comprising of some 22 countries were contacted along with Australia, Canada and the US. Australia and Canada were strongly recommended as contacts and having well-documented history.

The countries who replied to the questionnaire are listed below along with a summary of the current status.

The questionnaire sent is given in Appendix II. Where a question was not answered the column is left blank.

Table 1 Reported practice in other countries

Country	Compensation applied			Application by		Notes
	Yes	Both	No	Law	Code	
Australia			x	x		Standards and trade bodies gave strong representation for temperature compensation. Trade commission declined to introduce change.
Canada		x		x	x	STA recognized since 1950s but started in the '70s. 75% of transactions now use STA. Voluntary introduction at both wholesale and retail levels. Strongly supported by main oil company. Eases stock and loss control.
USA						
Netherlands		x		x		
Austria			x			Assume seasonal variations balance losses/gains.
Poland			x			
Switzerland	x			x		Only compensated deliveries by law. Reason 'Honesty of Trade'.
Spain			x			Problem recognized but not yet addressed by authority.
Germany	x			?		Seems trucks are loaded compensated but not a legal requirement, only free market agreements.
Sweden			x			Not covered by law. Treated as free trade.
Ireland			x			
Denmark			x			
Czech Republic			x	x		Current sale by Mass? Will change to compensated volume next year.
Iceland			x		x	Supply of fuel is unregulated.
France			x	x		Recognise unfair not to compensate but no driver to change

All replies indicated that compensation would use 15°C as the base temperature. Where used, most countries suggested the ISO/OIML/API tables would be used for expansion factors. Germany publishes at regular intervals a statutory value for both density and expansion factor. Where both compensated and uncompensated deliveries co-exist, the choice seems to be unregulated but all paperwork and hardware has to show clear marking.

Compensation equipment is verified by pattern approval and verification according to OIML R117. This equates to approval of thermometers to ±0.5°C and verification to ±1°C. An Institute of Petroleum Draft Guide covers this in more detail and calls for tighter standards.

Australia and Canada provided detailed reports of the status and practice in their countries. Both countries have wide ranges of ambient temperature.

The Australian report issued by the National Standard Commission in 1996 was extremely robust in recommending a move to full temperature compensation of fuel from terminal to customer. Backed by references to a number of independent, and apparently very thorough, studies of the metrology, the science, the legal implications and the economics, a very strong case for full compensation is made. It appears however that an equally robust case was put forward by the oil industry as to why compensation would be uneconomic. These reports were not provided, but their content is addressed by the Standards Commission and reported to be flawed. In the terms of this study no evaluation of the opposing arguments could be performed but the strength and independence of the Commission case is certainly impressive. Current information suggests that the law and regulation have not been changed and uncompensated deliveries are being maintained.

Canada also submitted documentation to explain the policy within Canada and it appears that compensation has been (and is still being) introduced in a much more reasoned and less confrontational way than has taken place in Australia. The large range of ambient temperatures provided the driver to recognize the need for compensation and this has been introduced on a voluntary basis at both wholesale and retail transactions. Legislation allows for both types of transactions to take place. Up to 4 years ago 75% of retail dispensers are compensated. It is unclear if a mix of compensated and uncompensated retail delivery and dispensing is allowed or practised. It appears that the driving force has been oil company cost reduction in oil loss control with the encouragement of the authorities to ensure fair trade. It is noted that a different pump price may be levied for compensated and uncompensated sales.

4.5 Government

4.5.1 Office of Fair Trading

The Office of Fair Trading consider that the current practices for fuel deliveries do not appear to diminish competition in the market place and hence they do not take a view.

4.5.2 DTI Consumer Affairs Directorate

Consumer Affairs does recognize an interest in the topic and wishes to observe what progress is made. They currently see the subject as a legal metrology responsibility and will rely on NWML to represent their interests.

4.5.3 Customs and Excise

Customs and Excise have two inputs to the process. For the collection of petroleum duty they are satisfied that the metering systems in place meet their requirements. Temperature is measured at duty metering points and duty is paid on STV. The fuel delivered to retailers is of no concern to this function.

The collection of VAT is based on the fuel received by the retailer and reconciled with the fuel sold. On an individual basis, allowance for loss, real or apparent can be agreed within the VAT structure.

In further contacts with C&E it is clear they have detailed legal framework for the control of product crossing the duty line. These documents must be considered in detail and much time and effort may be saved by ensuring, where possible, compatibility between their requirements and any new regulation is achieved. C&E have successfully combined the

mandatory requirements of their regulation with the recommendation to follow IP recommendations, guidelines and standards. This model should be examined while drafting new weights and measures regulations.

4.5.4 DTI Oil and Gas Directorate

This directorate of DTI was not approached initially by NEL but subsequent to the draft report expressed an interest in the topic. DTI did not consider a formal response appropriate but provided the following comments. They were broadly in agreement with the concepts and recommendations in the report as providing a fair basis for trade. They did express a concern over potential added costs to the industry and the need to control them.

4.6 Others

4.6.1 Institute of Petroleum

No clear consensus of opinion was taken from the Institute of Petroleum contacts regarding the implementation of temperature compensation. The recognition that correct measurement practice called for implementation of STA was tempered by a concern over the practical aspects and costs of implementation. This was with regard to the technology and standards to be applied.

The recognition of good measurement practice for gantry meters was clear in the current round of improved standards, which include meter calibration practices and temperature measurement practice. It was made clear that the high standards of calibration practice recommended by IP should not be compromised by relaxing to OIML or Weights and Measures specifications. The higher quality industry practice and standards should be retained.

Some concern over government regulation interfering with the free market of industry was expressed.

4.7 Seminar

A seminar at which the draft report was presented was hosted by NWML in Teddington on 11 March 1999.

There were 25 attendees and the list of names and affiliations as noted by NWML is attached in Appendix VI.

Mr Badger from NWML introduced the project and the appointment of NEL. Mr Paton and Mr Boam from NEL then presented the draft report and the reasoning behind the content and the recommendations. Questions and concerns of the participants were noted, answered if possible, and have been recognized in the preparation of the final report.

Subsequent to the seminar NWML, representative bodies and individuals provided a range of additional information, corrections to fact and some opinions, all of which have been recognized within the final report.

5 EXISTING LAW

The present situation is the measurement of fuel for delivery to forecourts is covered by the Weights and Measures Act 1985, and subordinate legislation under that Act, namely the Weights and Measures (Liquid Fuel carried by Road Tanker) Order 1985 (SI 1985/778) and the Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1983 (SI 1983/1389) as is the measurement of fuel into tankers using metering systems.

The controls take two forms - some general, and some more specific. As a general requirement, Section 28 of the Act prohibits the "delivery of a lesser quantity than that purported to be sold".

A further general requirement is found in section 17 of the Act that prohibits the use for trade of any measuring equipment that is "false or unjust". What constitutes "false or unjust" is not specified in the Act, and does not appear to have been addressed in case law to an extent that would enable anyone to say with certainty exactly what is an acceptable/unacceptable level of accuracy.

The Weights and Measures (Liquid Fuel carried by Road Tanker) Order 1985 (SI 1985/778) requires fuel carried by a road tanker to have associated with it certain documentation stating,*inter alia*, the quantity of fuel to be delivered.

The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1983 (SI 1983/1389) applies to "measuring equipment on road tankers for use for trade …" (Reg. 3(1)), and "prescribes" such equipment for the purpose of Section 11 of the Act. This in turn requires each individual item of equipment to be "passed as fit for use for trade" by an Inspector. The regulations lay down constructional criteria and specify acceptable errors. Reg. 7 states that "Measuring equipment … shall consist of a contents gauging system, a dipstick measuring system or a meter measuring system." If in the circumstances of a particular transaction those items are not "in use for trade" (perhaps because the contract specifies that the quantity is determined by the gantry meter), or the tanker is not in fact fitted with any such system, then these Regulations do not apply.

In the context of bulk fuel deliveries of petroleum spirit, for a variety of reasons, it is impracticable - and many Trading Standards Officers will say it is impossible, to ascertain the actual quantity delivered to the necessary accuracy to satisfy an essential requirement for any criminal prosecution - namely that the facts are proved "beyond any reasonable doubt".

It is likely that should a prosecution be mounted in respect of, e.g., a gantry meter, the court would have regard for the tolerances laid down in more specific legislation relating to other types of equipment, and this could well result in unacceptably low standards of accuracy being set by the Courts. (Retail fuel dispensers, and bulk fuel meters are permitted 'in service' errors of 0.5% in deficiency or 1% in excess. Since these are arguably acceptable, *de minimis* errors, it seems unlikely that a court would hold that errors of as much as even 2% were "false or unjust"). It would be unacceptable that the outcome of any case would depend upon case law (and initially upon the whim of an individual court) rather than on regulation, standards, or accepted good metrological practice.

Where dipstick measuring systems are used, modern health and safety standards will prevent the practice of tank dipping, and hence one of the objectives of the regulations, namely the ability of the purchaser to verify the quantity delivered, cannot be achieved.

This must be an unsatisfactory situation where the eventual outcome of any investigation will depend on case law and not on regulation, standards or good metrological practice.

6 FORMAL RESPONSES

The opportunity to include a formal response, of at most two pages, was given to the representative organizations involved in the study. To ensure that all aspects of the study were addressed the organizations were invited to respond and requested to address a number of issues specifically, as well as to submit their own opinions. A copy of the invitation letter is given in Appendix III. In addition to the formal response any additional information was welcomed and this has been summarized in the appropriate industry section. Individual members of organizations were also invited to reply and their responses have also been summarized in the specific industry sector reports. No attempt has been made to rationalize differences between the formal responses and the individual contacts.

The following organizations were invited to submit a formal response.

Organization	Response
APEA	Not a representative body and hence unable to form an opinion at this time
AUKOI	Response attached
IP	Unable to formulate an agreed policy in time available
ITSA	Response attached
InstTSA	Response attached
LACOTS	Response attached
PRA	Response attached
UKPIA	Response attached

These formal responses have been reproduced in Appendix IV.

7 DEPOT SURVEY

As mentioned in Section 4.2, a survey was carried out to assess the level of temperature monitoring and the typical ranges of temperatures seen at oil depots. The survey form, reproduced in Appendix V, was distributed to a wide range of depots. Some oil companies had already supplied contact information for their depots and the survey form was sent direct to these depot managers. Other oil companies were approached through their UKPIA representatives. In addition, some independent storage companies were also approached.

In all, replies were received from 6 companies covering some 16 depots. The depots covered a wide geographical area from the South West of England to Central Scotland and covered all types of supply source:

- direct refinery storage 4 depots
- pipeline-fed 3 depots
- sea-fed 8 depots
- rail-fed 1 depot

The annual throughput of these terminals was about 20-25% of the UK annual sales of petrol and diesel fuels. Thirteen terminals reported temperature data, mostly as annual averages with a seasonal spread. It is not known whether these data were the average of spot readings or were volume flow averaged.

The detail supplied varied from depot to depot as well as from company to company. The most detailed data came from two sea-fed terminals with one supplying daily average data for the 1st, 14th and last day of each month during 1998 and the other supplying monthly average data for the same period. The daily data for diesel are shown in Fig 11 alongside the long-term monthly average temperatures for the area; a better comparison with local daily ambients for 1998 was not possible. Fig 11 shows clear seasonal trends in the daily-average fuel temperature and also shows that ,for this terminal, diesel fuel temperatures at the gantry were about 2°C warmer than the long-term ambient. The fuel temperatures for successive days (last of one month and first of the next) show that fuel temperatures are very stable over short time intervals indicating that the storage tanks have large thermal inertia compared with the heat transfer rates to and from ambient.

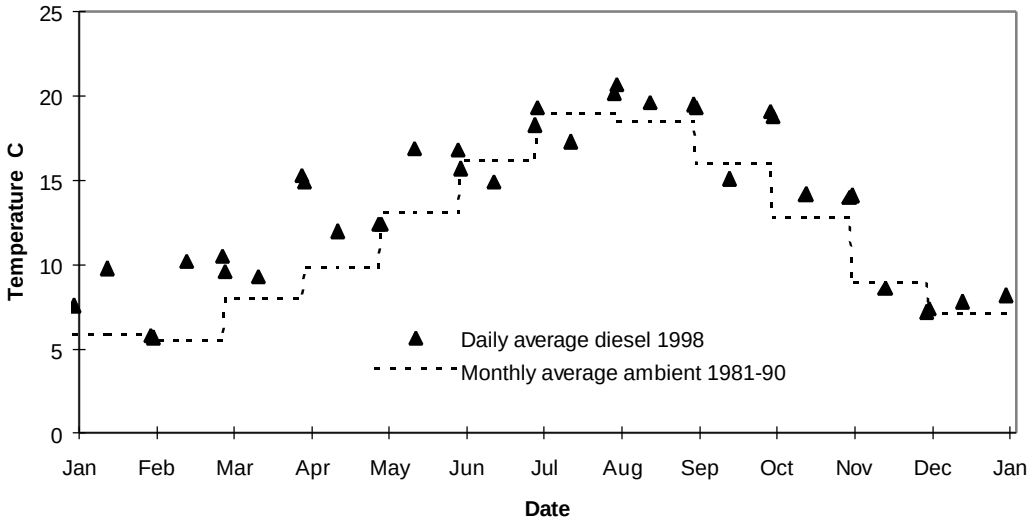

Fig 11 Variation of daily mean fuel temperatures and monthly mean ambient temperatures at a sea-fed terminal

The monthly-average data for petrol from the second sea-fed terminal are shown in Fig 12 with the long-term monthly ambient temperatures for the area. Again it can be seen that fuel temperatures at the gantry follow the ambient fairly closely. Fig 12 also shows that at this terminal the average petrol temperature is about 3°C above the local ambient.

Other depots reported operating temperature ranges and these are shown, grouped by fuel source, in Figs 13 and 14 for petrol and diesel respectively. These plots show that there are considerable variations between depots, both in terms of operating range and of mean temperature. It is difficult to isolate trends between fuel sources, but it can be seen that, with one exception, annual mean temperatures lie in a band between 10 and 15°C. Also shown on Figs 13 and 14 are the volume weighted mean temperatures for the appropriate fuel. A comparison of the data on Figs 13 and 14 shows that, for the terminals reported, diesel is typically between 0.5 and 1.5°C warmer than petrol at the gantry meter.

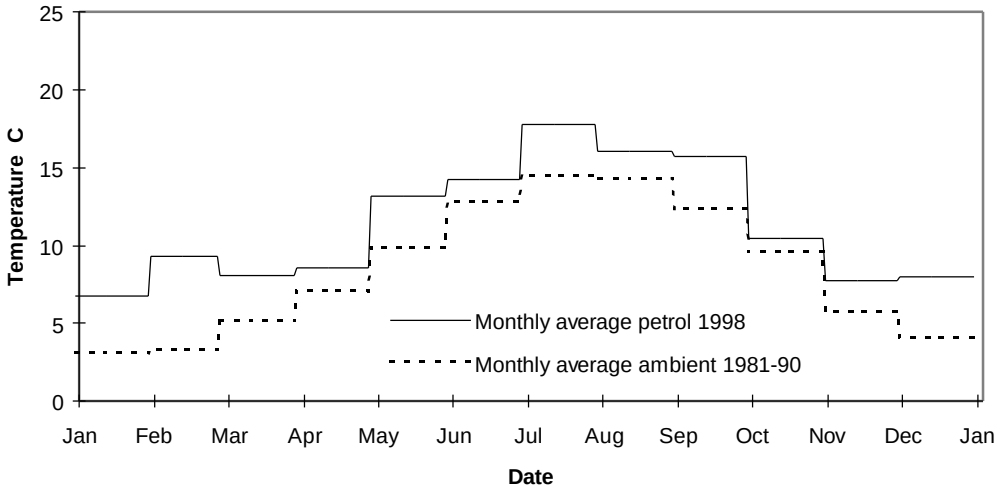

Fig 12 Seasonal variation of fuel and ambient temperatures (sea-fed terminal)

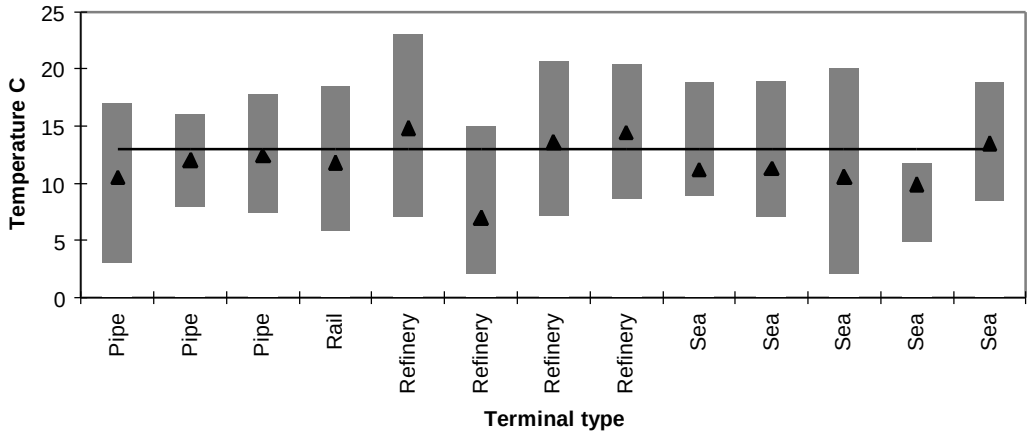

Fig 13 Operating Temperature Range for 13 terminals Petrol

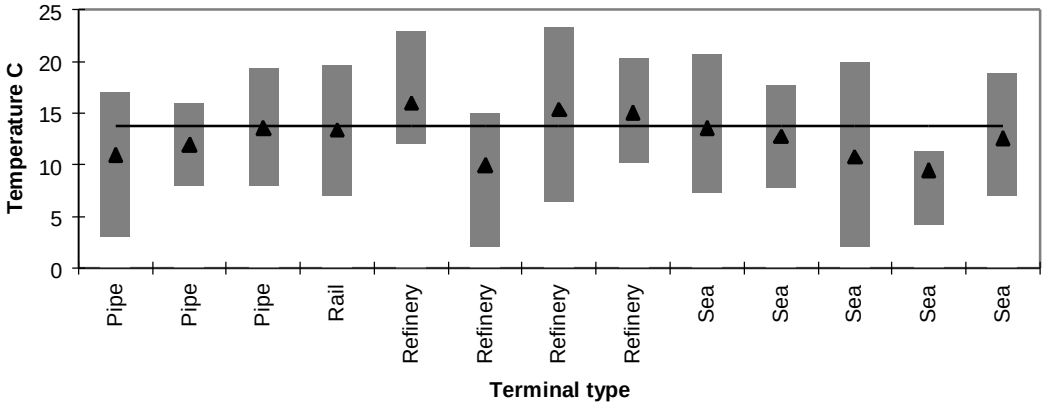

Fig 14 Operating Temperature Range for 13 terminals Diesel

The data from PRA and retailers (Section 3.4) indicated that greater losses are experienced when fuel is supplied from refinery terminals and, with less time for fuel to reach thermal equilibrium with the surroundings, refineries might be expected to produce the highest product temperatures. This was the case for 3 of the 4 refinery-based depots, the fourth reported the lowest temperatures of all terminals. The difference in mean supply temperatures from the 3 warm refineries and all non-refinery depots was 2.8°C (±1.8°C) for petrol and 3.4°C (±2.3°C) for diesel, the confidence intervals being at the 95% level. These mean temperature differences would represent volume changes of 0.34% for petrol and 0.27% for diesel, values that are comparable with the differences in losses reported in Section 3.4.

The general conclusion from the data supplied is that yearly average temperatures are below 15ºC and are within 2 or 3 degrees Celsius of ambient. Seasonal trends follow the variation in local ambient temperatures.

8 DISCUSSION

It is a fundamental principle of weights and measures that the measurement of a quantity for trade is fair and just. To achieve this the measurement should also be accurate.

The purpose of legislation and regulation is to give this principle a legal framework within which trade can function with confidence on both sides of a contract.

The current and future situation regarding the delivery of bulk fuel from road tankers shows that the legal framework does not match modern practice. It is the purpose of this report to recommend ways that the future legal framework should reflect the current and future methods of commerce regarding the deliveries of fuel and to comment on the metrological and legal requirements to ensure fair and just measurement is carried out. As an integral part of the UK National Measurement System, NEL also has an obligation to take into account the promotion of good metrological practice and to suggest how this can be applied to the benefit of industry and trade. This should consider not only present practice but must look well into the next millennium.

It is clear from the survey that the current situation on metrological control of deliveries of fuel is untenable. As the practice of dip measuring road tanker volume is no longer acceptable this alone requires modification to the existing regulations to reflect the future practice. It is also clear that the amount of dissatisfaction among retailers with the current measurement basis for trade has to be addressed.

The two issues, although linked have been addressed separately. Other related issues involved in the transfer of fuel have also been addressed.

8.1 Requirement for STA

The principle of STA is accepted and encouraged throughout the oil industry until the final two stages of the delivery chain - delivery to the retailer and delivery to the final customer.

Where correction is introduced it is recommended that the industry standard of 15°C should be the standard temperature adopted in UK. The relevant ISO volume expansion tables should be called on as the default correction factors unless research shows them deficient for modern fuels, see Section 8.10.

The reason that correction is not applied at present is probably historical. The complexity and capital costs of fitting temperature compensators or calculating temperature corrected volumes were not justified in terms of the quantity, distribution and value of the product traded. It was also evident that stock levels of fuel were high and the temperature of fuel was consistently closer to ambient than is the case in some ex-refinery delivered products today.

This situation now no longer exists with almost all gantry metering systems being fitted with remote or electronic reading of volume and temperature and a suitable controlling computer. Installation of software, where it does not already exist, to calculate STV and print volume, temperature and STV is unlikely to provide a major problem to distribution depots. In fact it is believed that such an advancement would improve the efficiency and internal stock control of the oil suppliers and this is recognized by the number of installations already equipped in this manner.

When the weights and measures principles are applied, the retailer can verify the quantity of fuel he is receiving using the volume measure provided by the tanker dip. He 'purchases' a verifiable quantity of product. As tanker dip measures are phased out the retailer has to 'purchase' a quantity of fuel measured elsewhere and not verifiable. This concept will be explored later in more depth. Unfortunately this is not the same as purchasing most pre-packaged goods. In fact the volume loaded is<u>not</u> the volume received. The retailer will receive more or less depending on the temperature change incurred during transport.

The logical conclusion of this argument is that trading in STV is the best metrological practice and should be encouraged and allowed in the regulation.

8.2 Ambient Temperature Accounting

It has been suggested that fuel should always be accounted for at ambient temperature. This is fraught with difficulties. Firstly ambient temperature has to be defined. At least four ambient temperatures could be recognized: at the loading meter; at the tanker after filling; at the tanker on delivery; or at the retail tank. This gives serious problems of contract conditions and of course both air and fuel temperature measurements have to be regulated at the chosen point.

Once defined, correction of volume to this defined ambient would have to be carried out in the same manner as would correction to a standard 15°C. This gives no advantage to ambient accounting over STA.

Alternatively, if the objective is to supply fuel at ambient temperature to minimize changes in volume, this again gives difficulties. To achieve ambient temperature the supplier may have to cool or heat the fuel. Equipment would have to be in place to carry out both tasks as 15°C fuel may have to be heated in summer and cooled in winter to come within ambient temperature. Cooling may reduce vapour losses but no justification for heating can be found.

8.3 Contractual Arrangements

Many would argue that it is not the place of regulation to define the contract conditions between supplier and client. It is by agreement between client and supplier that a contract should be based on measured volume or STV. It is however the place of regulation to ensure that the measured quantity is accurate, just and clearly indicated. It is also the

place of regulation to ensure unfair practices in contracts are not applied. It is therefore recommended that regulation should be brought in to specify the indication of 'measured volume' or STV, and, if both are quoted, which is the basis for the trade.

8.4 Visibility of Quantity Delivered

Warm or hot fuel being delivered to a retail tank will cool and therefore show an apparent loss based on measured volume. If of course cold fuel is delivered the opposite is true but is rarely of concern to either the retailer or the TSO, and is probably less likely to occur in practice. If the apparent loss exceeds what is considered to be the normal condition this apparent loss has to reported to the local petroleum officer as potential leakage. Some officers suggest a guidance value of 0.5% departure from the norm. If not accounted accurately this can lead to expensive and time-consuming investigations for the retailer, supplier and the authority. Clearly an indication of the actual quantity of fuel delivered rather than only the volume would assist greatly in separating true losses from apparent ones.

As many small and rural stations will not possess accurate tank gauging for some time, and, due to the acknowledged poor standard of maintenance and accuracy of existing equipment, level and temperature of the retail tank will not provide a reliable estimate of quantity. TSOs are being inhibited in their investigations, and retail operators put to considerable expense by not being able to estimate to within 0.5% the quantities of fuel delivered to them and residing in storage.

A separate concern is the visibility of the quantity of fuel delivered within a contract arrangement. Based on the information supplied, it is accepted that, while losses may arise from evaporation and from mean temperature levels, on average, across the UK, and across all retail sites, little is gained or lost by variations in temperature within contracts. It is, however, almost certain that, for some localized deliveries in certain areas (or at certain times or from certain supply depots), some retailers can be disadvantaged; others will probably be advantaged. The adoption of STA would alleviate this problem for operators who choose to adopt it in their contracts. At present where disputes arise over contracted deliveries neither side can demonstrate reasonable information to substantiate the position.

Some suppliers recognize that there is a balance of probability that bias exists in the temperature of delivered fuel and hence provide compensation allowances for this on an individual and geographic basis. This will be offered within contract to some retailers even when the fuel is not being delivered warm or hot. The visibility of these allowances is very poor and unavailable to many retailers.

For both the reasons above it is recommended that a mandatory indication of the fuel temperature at the loading meter be added to the delivery/invoice note. This will clearly define the point of sale as the loading meter and define the quantity.

Although not indicating the temperature of the delivered fuel, this will assist to investigate apparent stock losses and will allow contract disputes to be settled more efficiently and amicably than at present.

Ideally, temperature of the delivered fuel should be measured either at the tanker or retail inlet. This is considered to be good practice but is not recommended for regulation due to difficulties of maintenance and policing. The industry in general should examine this

concept and install delivered fuel temperature measurement as part of tanker or forecourt design where an economic benefit can be demonstrated.

To allow better instrumentation, two suggestions are proposed:

a) The provision of temperature measurement pockets could be specified in all new installations, at little added cost, and retro-fitting to existing delivery points may not be difficult. Oil loss auditors and TSOs can then utilize these points with portable insertion thermometers when required.

b) Manufacturers of tanker sealing equipment should consider adding outlet temperature recording and indication to the equipment. It is not clear at present how this could be used to impact on the contractual volume delivered but a reliable recording would go some way to resolving many of the uncertainties of the present situation regarding environmental losses and stock control. A similar measurement could be made at the retail tank inlet. It is stressed that these measurements would be for stock control and should not be regulated. Moving the point of sale to the loading meter means that these measurements could have no contractual significance except as an indication of stock loss problems.

The verification of deliveries (or loading), it was suggested, could be carried out by mass. The tanker would pass over a weigh bridge at the loading depot or close to the retail site. Although the theory is good it is suspected that to provide the degree of consistency required, the weigh bridge would have to be at the loading bay, which is not practical for cost reasons. If a weigh-bridge was available this could be used as a verification tool but this approach is fraught with difficulties.

8.5 Sealed Deliveries.

The current legislation allows for the quantity of fuel delivered to a customer to be verifiable through the use of calibrated tanker volumes and inspection of the dip sticks by supplier, customer and TSO. While it has many faults and suffers inaccuracies and misuse, it does comply with the principle of weights and measures practice.

Health and safety considerations are now fairly clear that, to avoid risk of falling and contact with petroleum spirit, dipping tanks as a witnessed operation will not be allowable. Further environmental legislation will make opening tanks to carry out a dip undesirable, and in fact dangerous if the tank is opened during a delivery with vapour recovery and positive pressure remains in the tank. These restrictions make compliance with weights and measures legislation impossible. Safety must take precedence and therefore weights and measures legislation must adapt to the current practice. The principle of verifiable deliveries has broken down and so alternative controls must be put in place to ensure fair and just trade.

The use of automatic tank gauging of either the truck volume or the retailer's storage tanks could be controlled and regulated. Either would meet the requirements, along with additional temperature measurement. Theoretically either controlling the truck gauging or the retail tank gauging would satisfy the requirement of monitoring the quantity of fuel delivered. It is believed however that neither the regulatory authorities nor the operators would wish to adopt this strategy. The costs of pattern approval and verification would be very high and the potential for misuse is great. As a result this approach is discounted on both technical and reliability grounds. Retailers' tank and truck tank gauging may remain useful as a cross-check but not as the primary proof of delivery.

The alternative practice is to deliver through tank truck metering. This technique is already regulated and as such is now permissible. However, technical difficulties exist in adopting the practice for petrol; outgassing of volatile fractions could, for example, lead to vapour bubbles passing through the meter, which would have an impact on metering accuracy. Adoption will also add costs and inefficiencies to the distribution chain. This approach is not recommended except for planned small, part compartment situations for DERV. As this method is well regulated it is not discussed further.

The quantity loaded onto a tanker, metered by the gantry system and sealed until delivery, appears to be the only viable alternative measurement method to give the confidence required by law and a situation where only the Weights and Measures Act applies is not tenable.

To recognize this it is recommended that the road tanker regulations be amended to make provision for this type of transaction. It is recognized that the method is well established and meets the requirements of the suppliers as giving good efficiency improvements to the distribution chain.

It is noted, however, that the quantity metered as passing into the tanker becomes the contracted quantity, not the quantity in the tanker or the quantity delivered. This distinction has to be recognized in both the regulation and the contract provisions. The point of sale moves to the loading meter. Any losses between the meter and the delivery point will remain unaccounted, as will any lost or gained volume due to temperature changes unless STA is adopted. Apart from malpractice, the main loss of quantity between meter and delivery will be vapour loss during filling and delivery, although apparent gain or loss due to temperature effects will remain significant.

Additional temperature measurement at the delivery point (tanker or retail inlet) would allow quantification of quantity delivered and volume changes but it is difficult to see how this could be incorporated in the contract agreement. It could, however, be employed for stock accounting. The designs should incorporate thermometer pockets for verification of the reading without implying the system itself is regulated.

8.6 Regulation of Sealing Systems and Tanker Design

To ensure retailer confidence avoid fraud and match the present provisions for tanker design and operation, the design and use of sealing systems and the tank empty indicators will have to be brought under metrological control. This implies pattern approval and verification provisions should be put in place. Sealing devices should be pattern approved and a verification regime established by self verification and TSO random inspection. Again this provision is in the interests of both supplier and retailer to minimize fraudulent transactions.

Consideration should be given in including temperature measurement of the delivered fuel within the sealing electronics and tanker outlet ports. This may or may not be prescribed with the sealing computer but could be used to aid stock control within the retail system.

As part of the amendment to regulation, consideration could be given to relaxation of the volume calibration and maintenance for tankers approved for sealed deliveries. This will provide significant long term cost savings to industry.

8.7 Control of Gantry Metering Systems

From the discussions some large independent retailers have serious doubts regarding the reliability and accuracy of gantry loading systems. As deliveries move to sealed deliveries small retailers become vulnerable to errors in the gantry metering systems without having the skill, knowledge or access to question the equipment. The present situation gives TSOs the power to investigate short deliveries from gantry systems under section 79(1) of the weights and measures act. In practice, without the specialist knowledge or test equipment, this is more a theoretical power than an actual one. Only checks on volumes loaded into tankers and comparison with billing can show discrepancies. In this event all the problems of volume temperature variation and access to the tanker come into play.

The suppliers also have a vested interest in maintaining gantry systems to a high standard to ensure accountability of oil stock within the depot and to retail outlets. This they already carry out to high standards. Independent inspection must however be established to allow visibility of these procedures.

To establish the verification and regulation of deliveries to the present level, it is recommended that the gantry metering systems be brought formally under metrological control.

It is well recognized in the industry that the calibration and control of gantry measuring systems have to be carried out. The IP has a number of standards in place and in preparation, providing codes of practice and standards of performance for gantry loading metering systems. At present gantry systems are calibrated and verified every four or six months, to tighter accuracy standards than would be normal in Trading Standards regulation. It is also recognized that the techniques and methods needed are specialist and can only be provided by expert company or contract staff and equipment.

To introduce pattern approval and initial verification on existing systems is clearly impossible and in fact unnecessary. The wide spread of systems that have worked satisfactorily for many years would make retrospective approval ridiculous. Similarly no requirement is seen for re-working existing procedures and design codes as regulatory documents. Existing industry standards of design should be adopted with the addition of sealing requirements for adjustments between calibrations.

A system of self-verification is advocated for the gantry systems. This removes the fears of the operators of regulatory interference in their business while ensuring visibility of standards and accuracies to their clients. Industry will have to provide the complete set of standards and a code of practice to satisfy the quality system and this would be done in consultation with NWML and LACOTS, but after that, the limited extra burden will be the quality system inspection by either TSOs or an accreditation body.

It is unfortunate that the OIML recommendations on metering systems for liquids other than water appear to be too lax. If this was not the case, or if they can be changed in future, gantry metering systems could be prescribed under the De-regulation (weights and measures) order 1999. NWML will have to address any conflict between UK industry standards and any OIML or CEN requirements. The oil industry may assist this process by agreeing the specifications and suggesting the relevant changes to OIML internationally rather than coming form UK alone.

8.8 Inspection and Accreditation

This would have to be addressed in a code of practice. TSOs in pursuance of complaints would have to have access to the quality records and the ability to witness the calibration of any system at the normal calibration date. The question of notification to TSO of impending calibrations will need to be addressed. The authority to require an extraordinary calibration would rest with the TSO but grounds for this would probably require documented doubt of the accuracy of deliveries. Such doubts would even now be pursued by reputable suppliers and calibration checks implemented without enforcement.

The choice of calibration/verification contractor would be a commercial one on the part of the supplier but it would assist the process and confidence if the calibration and verification were carried out by accredited staff and methods. This is needed to show independence and competence. As currently no independent accreditation is in place for the contracting companies', oil suppliers' in-house calibration teams or TSO verification teams should they be established, this will require some work. Accreditation could be through UKAS and incorporate the use of NVQ training of staff. Full NAMAS accreditation, although desirable, may prove to be overkill. In the unlikely event of concern over the independence of the calibration contractor, the code of practice should recognize the need for independent auditing or change of contractor on TSO advice.

None of the above is an unusual procedure to be put in place and is probably standard practice at present. Where many different brand products are dispensed from one depot, the open and witnessed calibration and quality record systems must already exist. Use of TSOs as independent witnesses may reduce operating costs by reducing the number of different inspections providing that the TSO's witness is accepted as independent.

Recognition is made of the need to establish expertise and training for specialist TSOs for this task. It has been suggested that TSOs should establish regional expertise and equipment to carry out inspections and calibrations. While centres of expertise for inspection are recommended, it is felt that equipment should only be established should the present private contractor regime prove to be unreliable. This should not interfere with the present market place. TSO verification teams should carry the same accreditation as contract or company teams.

8.9 Deliveries and Part Loads

Clearly the proposed changes cannot apply to part loads. Part loads must be either accounted for by tank dips or by metered deliveries.

No recommendation is given on how to cope with accounting for a frustrated sealed delivery. Consultation between the industry and NWML will have to be carried out to solve this problem.

8.10 Expansion Factors and Standard Temperature

In Germany an assumed legal density and expansion factor for grades of fuel are published at regular intervals. Most other countries use the ISO 91-1 tables for products to derive expansion factors but it unclear how they specify density. It is recommended that, with the assistance of industry, NWML establish and monitor a base assumed density for common fuels and specify the ISO 91-1 (Petroleum Measurement Tables - Part 1: tables based on reference temperatures of 15°C) for expansion factors unless these prove to be unacceptable. It would seem unproductive at this time to require the density to be monitored and controlled by the supplier at all times but should this be required the specification and method will have to be defined. C&E require one measurement per batch of oil delivered to storage as a minimum requirement. For quality reasons the density of fuels delivered will be monitored, so perhaps the industry code of practice should provide a range around the 'standard' value within which the fuel should fall to give no significant change in expansion factor.

It is recommended that the ISO 91-1 Petroleum Measurement Tables be used for volume correction. It is insignificant to the application, if the full implementation of the table with temperature and pressure rounding is used but to ensure clear understanding each installation must be marked or make available in the quality system the calculation methods used to implement the tables.

It is unlikely that pressure correction is required.

8.11 Vapour Losses

Although outwith the specifications of the study, the question of accounting for vapour losses at each stage of the distribution chain was of clear concern to the participants. Vapour recovered from the motorist to the retailer is not a new loss to the motorist as the same vapour would have been lost to atmosphere. Similarly vapour recovered from the

retailer to the tanker is what was previously lost to atmosphere. This loss however is measurable as apparent loss of product delivered from that sold and hence an estimate should be available. It is noted that vapour recovered at this stage may contain more hydrocarbon product than was previously lost to atmosphere due to different system pressures being created in the process. As it is the retailer's product, the recovery of vapour to the tanker as against loss to atmosphere could be seen as a case for allocating a value and may require an allowance. On the other hand a charge for removing the vapour safely to allow compliance with legislation may be more appropriate.

Of much more concern to the measured volume is the vapour recovered from the tanker while loading. Metering at high pressure and temperature will give rise to larger amounts of vapour being released from the liquid phase in the tanker and then recovered after being measured as delivered product. It has been difficult to obtain estimated figures but it is recommended that the industry comes together to investigate the physics of vapour release under these conditions, and to produce guidelines limiting the delivery pressure, temperature, and methods to minimize this vapour loss for environmental reasons. Estimating the loss above agreed limits may have a metrological importance and require an allowance to the delivered volume.

8.12 STV at Dispensers

Again outwith the scope of the study is the question of applying temperature compensation to dispensers. There are clear logical and metrological reasons for the application of STV right through the supply chain to the dispenser. Significant metrological benefits can be shown by STA from gantry to retailer, but to obtain the full benefit in terms of oil loss accounting, the final step has also to be taken. The cost of implementation, £300-£700 per dispenser, is not high compared with the potential long term accountancy benefits and cost savings that could be realized. The cost quoted was provided by manufacturers and expresses the range of costs from a single-nozzle new-build dispenser to a multiple-nozzle dispenser being retro-fitted. To convert all dispensers in UK would clearly be impossible in the short term. Set against annual retail sales of about 10000 million litres, the total cost of some £40m is not the significant factor as long as the introduction is undertaken as a long-term process through replacement and major refurbishment of dispensers. Dispensers generally have a life of between 5 and 15 years with most being replaced or refurbished within 10 years. Voluntary introduction through the replacement/refurbishment route would be the preferred option with total legislative change only coming in after 90% conversion.

The introduction of STA is not felt to be significant at this time for fair trade to the customer but more an improvement in stock control and accountancy. For this reason it is recommended that the regulation be put in place to allow and control STV deliveries at the dispensers. No compulsion should be put on implementation without the support and agreement of the industry. Should this be forthcoming it is suggested that implementation would be phased in by first making the capability mandatory on all new pumps and installations but only implemented on stations where conversion is complete.

Again it is stressed that this is outwith the scope of the study and the recommendation is that the regulation be changed to enable STV trading at the dispenser when the industry is ready.

8.13 Other Issues

a) Legislation

In principle the changes should reflect the requirement to allow STV deliveries to be made and temperature reporting to be mandatory. Changes should be drafted to allow the dispensing of STV and the clear differentiation between the type of transaction. The Canadian legislation on these changes could be used as a model. As an aside it would be prudent to build in provision for trading in mass as this could be possible in the next five to ten years. It is not recommended that any suggestion of compulsion be provided on STA but instead only that 'enabling' clauses are inserted.

The requirement to show the loading temperature along with the loading volume should be inserted in the appropriate legislation.

Both the above changes can be implemented within the two road tanker regulations. The recognition of STV may have to be reflected at a higher level.

The extent of legislative effort to bring the loading and sealing systems under control is more difficult to detail in this report. In principle the legislation should reflect the best of current industry practice and call on the industry codes as the basis for the testing requirements. Where a code does not exist this is best provided by the industry rather than the government body. It is not clear where in the legislation this change should be made.

b) Implementation

It is suggested that regulations changing practices for tanker operations to cover sealed deliveries will take at least five years to come fully into force. During this time the main work will be establishing the self-verification regime, and the pattern approval of tanker sealing systems.

Changes to regulations to allow STA could be put in place within three years.

The mandatory addition of temperature to delivery invoices would be best made final in the year 2004, coincident with other environmental regulation for vapour recovery. Complying with this will involve gantry updating and hence temperature can be added at this time. It would be expected that most systems would be converted prior to this date.

This also ties in well with the retail supply contract cycle, which is commonly five years.

c) Economic impact of STA

Adopting sealed deliveries from controlled loading systems with temperature data will provide a much more robust and technically satisfactory solution to both contractual and measurement problems than is currently the case. Adoption of STA would increase the efficiency of the operation further. It is realized that none of these proposals fully addresses all the measurement problems or accounts for all the losses.

Should the retailer receive STV deliveries they will still show a gain or loss of volume as the temperature in the retail tank changes. A future change to STA at the retail dispenser will be required to show a reasonable balance between fuel delivered and dispensed.

Apparent losses in the tank due to shrinkage with temperature will still be seen for environmental reporting unless retail tank temperatures are accurately measured.

It is reported by the suppliers that the balance of loss and gain of fuel volume due to temperature expansions and based on a 15°C norm is equal across the country. A move to STA will not change this position. The apparent losses and gains will be redistributed with potentially the small retailer supplied from a warm source reducing apparent losses while the large retailer fed from cold sources will show slightly higher losses (or lower gains). This is of course speculative.

It is believed that, if as reported, the current system shows no net gain or loss to the suppliers, a change to STA will maintain this overall position and cost savings due to better accounting and contract conditions will offset the capital investment.

d) Oil loss control by the retailer

Apparent losses in retail storage will occur as long as fuel is delivered warmer than the storage temperature or until reliable STV delivery, dispensing and tank gauging is introduced. Introduction of STV at any stage will reduce the uncertainty, and better maintenance of equipment will have an even bigger effect; meanwhile temperature recording of fuel in tanks and of deliveries will allow some estimates of shrinkage to be made.

The other main loss is that of vapour, occurring when the tanker is filled, when delivery is made, and during storage. Improved forecourt systems are significantly reducing the third source of loss but the other two should be accounted. It is outwith the scope of this report to examine this and it is recommended that a joint industry approach be adopted to provide better reduction of these losses and agreed accounting procedures for them.

9 SUMMARY

Good measurement practice gives rise to better and fairer trade. Good measurement practice should reduce the requirement for regulation by allowing all parties in a contract to believe the terms of the contract are being adhered to. When buying any goods it is expected that the supplier's measurement of quantity is correct and that the quantity measured is the same as the quantity delivered. This has to be accomplished within a sensible legal framework. Nobody wishes to pay significantly more for goods to cover the costs of ensuring accurate measurement. A balance must be struck and this is the objective of this report.

To ensure the volume of fuel purchased is the same as that delivered, the fuel must remain at constant temperature. This is impossible. Purchasing a mass of fuel would be the best measure, but mass meters are not yet acceptable to the industry. Volume corrected to a standard condition is the next best option. This report recommends a change of industry practice to Standard Temperature Accounting. It is believed that this will give rise to better, more honest and just trade in fuel, better oil loss control, and lower costs to the distribution operation. The information gathered suggests that such a change is not fully supported by a significant part of industry and so it is difficult to recommend any mandatory introduction of STA. Contracts between supplier and customer should take precedent.

It is the right of any retailer to see clearly the quantity of fuel he purchases to ensure fair trading. The retailer requires to know the quantity of fuel he purchases both to identify

losses to comply with environmental legislation and to balance VAT accounts. For this reason the retailer is entitled to know the temperature of the fuel when it was sold to him. Assuming the point of sale moves to the gantry loading meter it must be mandatory to print fuel volume and corresponding temperature on delivery notes. It should be clear if measured or standard volume at 15°C is being used.

It is recognized that this does not fully allow estimates of volume changes due to temperature between loading, delivery and retail storage. It is therefore proposed that road tankers and/or retail delivery points be fitted with suitable temperature measurement points to allow estimates of volume changes for stock accounting purposes but these would not be applicable to the contract quantity.

As the point of sale is moved from the delivery point to the tank loading meter, confidence in the metering systems, and the sealing of the 'package' of fuel must be assured. It is therefore required to establish regulation of both the metering systems and the tank sealing systems to avoid malpractice and lack of trust in the measurements. This however has to be accomplished in a technically difficult area and without significant increase in cost to the oil supplier. It must also be accomplished without erosion of the already high standards of measurement within the industry. It is proposed therefore that a regime of self-verification be established for the metering systems with TSOs providing an auditing and complaint investigation role rather than a pro-active verification role. Tanker operations have to be brought under better control with regulation of sealed deliveries and prescription of the systems.

The industry has to investigate, control, minimize and account for vapour losses in the delivery system.

Fifteen recommendations have been made.

10 RECOMMENDATIONS

It would be expected that this study would provide a number of recommendations. It is clear that these must be based on what constitutes the best metrological practice to allow existing Trading Standards law to be brought into the next millennium. These recommendations therefore recognize the practices currently in place and the practices being adopted for the future. It is hoped the recommendations will promote best measurement practices for the future and set a framework for metrological control.

It is now for the regulators and the industry to agree on the form of the changes to provide a clear legal framework within which fair and just trade can progress with a minimum of regulation.

1) It is proposed that regulation be amended to recognize Standard Temperature Accounting throughout the delivery chain from supplier to final customer. This should include deliveries to forecourts and dispensers.

2) Regulation should cover the requirements for indication of Standard Temperature Volume, dual marking and pricing.

3) The regulation should provide for the establishment of 15°C to be the Standard temperature and that NWML be responsible for the definition of volume correction factors to meet the requirements of current fuels. (Standard industry tables (ISO 91-1 will provide the first estimate.)

4) It is proposed that no regulation be brought in to require the adoption of Standard Temperature Accounting. This decision should remain within company contract agreements.

5) The regulation covering the delivery of fuel by tanker to be amended to recognize the point of sale as the loading meter and quantities sealed at point of loading.

6) To ensure that the quantity of fuel being traded can be better estimated for both contract and environmental reasons, regulation should be brought in to ensure measured volumes loaded into tankers show the temperature of the fuel at the metering point. This should apply to both actual volumes and standard volume measurements.

7) The provisions for regulating, approving and verifying sealing and tank empty indicators to be urgently addressed.

8) It is recommended that the current requirements for tank volume verification and dipstick calibration be relaxed for tankers designed for sealed deliveries.

9) Loading meter systems (gantries) should be brought under metrological control based on a system of self-verification and audit by TSOs. It is strongly recommended that IP codes be used as the standards to be met, as relaxation to OIML/Trading Standards specifications is considered to be too lax. The extent of notification and inspection by TSOs has to be agreed.

10) Within the above audit scheme the provisions and powers of TSOs to investigate concerns regarding deliveries must be well defined to balance the need for policing the system and the costs involved in over-regulation.

11) Industry should implement accreditation of teams involved in calibration of metering systems. This could be an industry initiative through UKAS. Accredited teams could be company personnel, specialist contractors or TSOs. Only accredited teams should carry out calibration/verification work on systems and should retain independence from the supplier and operator of the metering systems.

12) No requirement for separate TSO verification of the systems should be introduced unless it is to investigate suspected false deliveries. In this event the verification should be carried out to industry guidelines and accuracy levels by approved or accredited teams agreed by the TSO.

13) NWML and industry should collaborate on regulation for part load and frustrated delivery from sealed loads.

14) Industry should examine the pressure and temperature effects on fuels with a aim to understand, reduce and account for vapour losses while filling tankers and delivering to forecourts. A code of practice to limit pressure and temperature at the metering points may be required. An estimate of volume losses as a function of temperature and pressure and delivery method may provide a model to assist in loss control and loss accounting.

15) It is recommended that all changes are fully implemented by 2004.

11 ACKNOWLEDGEMENTS

NEL would like to express their thanks to all who contributed to the study. The time, frankness and general assistance have been much appreciated.

A P P E N D I X I

SPECIFICATION FOR THE STUDY

Temperature Compensation of Liquid Fuel Measurement

Short Description:

The aims of this consultancy project are to investigate the effect of the temperature of the product on the measurement of liquid fuels (petrol and diesel), and to recommend any regulatory changes that might be justified in the light of technical and commercial considerations.

Background

In the UK, the volume of motor fuel invoiced to the petrol retailer is predominantly based on the measurement of the fuel into the road tanker at the company's distribution terminal. Petrol retailers may suffer real or apparent stock losses due to a number of causes, including fuel contraction due to a temperature difference between the fuel as it passes through the meter at the distribution terminal and the underground storage tanks at the petrol station, from which petrol is sold to individual motorists.

The extent of this contraction and its commercial significance have been the subject of debate for many years. In a recent paper, the Petrol Retailers Association (PRA) claims that legislation governing the measurement of bulk motor fuel has not kept pace with changes in the industry, does not accord with current commercial practice, and is grossly unfair to the petrol retailer. The solution proposed by the Association is an amendment to the regulations affecting the measurement of liquid fuel carried by road tankers to require measured volumes to be corrected to a standard ambient temperature of 15ºC.

Information about practice in other countries is patchy, although it is understood that some European countries, including Germany, correct measurements to a standard temperature. Australia and Canada have also recently completed studies of the problem, although they have wider extremes of temperature to contend with.

Following representations from the PRA and others, Competition and Consumer Affairs Minister Nigel Griffiths has asked the National Weights and Measures Laboratory (NWML) to look into the various issues raised and advise him whether legislative changes are needed.

The Legislation

There are two pieces of secondary legislation made under the Weights and Measures Act 1985 which apply to the delivery of motor fuel from tankers. The Weights and Measures (Liquid Fuel Delivered from Road Tankers) Order 1985 prescribes the documentation requirements for the carriage of liquid fuel, requiring a document to be associated with the cargo showing the quantity of fuel loaded and the quantity to be delivered. This document must be delivered to the recipient of the fuel. The measuring equipment mounted on road tanks is prescribed by The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1983 (as amended). Under the provisions in these Regulations, it is unlawful to use such equipment for trade purposes unless it has been tested and stamped by an inspector of weights and measures. No such legislation applies to meters installed at terminals.

Technical and Commercial Issues

The key technical issue relates to the practicality of measuring the temperature reliably and applying the results in a realistic manner. The incorporation of thermometers at distribution terminals or directly on tankers may present significant technical difficulties and prove expensive. The cost of operational and metrological maintenance (recalibration) would have to be taken in effect. These costs would inevitably fall on the retailers and ultimately on the motorists, and it will be important to balance them against any benefits that might result from the introduction of temperature compensation.

Any volume adjustments assume a knowledge of the thermal expansion coefficient of the fluid in question, and doubt has been expressed by the PRA about the validity of figures in standard petroleum tables. The figure is likely to be different for different fuels anyway, and a complete range of specific up-to-date data would have to be available.

The Project

The project will involve consulting a range of interested parties in industry and government on the technical and commercial issues involved before making recommendations.

i) consultation with interested parties in DTI and OGDs, local authorities, PRA and the petroleum industry;

ii) investigation of solutions implemented in other countries;

iii) analysis of possible technical solutions and their commercial viability;

iv) identification of compliance costs of proposed solution(s);

v) discussion of emerging findings with NWML and their legal advisers;

vi) preparation of final report with recommendations.

Deliverables

In addition to interim reports on specific matters, the principle deliverable will be the final report, which will recommend what action if any should be taken by the Government, with analysis and justification as appropriate.

A P P E N D I X I I

TEMPERATURE COMPENSATION OF LIQUID FUELS

Other Country Practice Survey

Country Name: Address:
Telephone: Fax: email:

1. Do you apply temperature compensation to fuel being delivered to forecourt service stations:

a) compensated only ☐
b) both compensated and uncompensated allowed ☐
c) uncompensated only ☐

2. If uncompensated, have you considered the problem with what result.

3. If compensation is allowed:
a) What is the base temperature**……**
b) What expansion factors are used for
Leaded Petrol **……** Unleaded Petrol**……**
Super unleaded**……** Diesel **……**
c) When was the decision implemented
d) Why was the decision taken
e) Was implementation by:
Legislation ☐ Code of practice ☐
d) Where is the temperature measured for each type of tanker operation:
i) dipstick and part loads ☐ ii) meters ☐
iii) full compartment loads ☐ iv) others ☐
f) How is the temperature verified and by whom.
g) Is pattern approval applied and to what standard and accuracy.

4. If both methods are allowed, how is the delivery differentiated.

Although directly part of this study the following supplementary questions may affect the result:

1) Are any other fuels covered by the same rules.
What is the position for LPG and LNG.
2) Is CNG regulated and is it traded by volume, standard volume or mass.
3) Has compensation for liquid fuels been applied at the dispenser.
If yes, please describe methods used. **Yes/No**

4) Has evaporation losses been considered from hot and cold deliveries. How has vapour recovery affected this?

A P P E N D I X I I I

LETTER TO INVITE FORMAL RESPONSES

Warm Fuel Deliveries to Filling Stations

As you are aware, we at NEL are carrying out a study for the National Weights and Measures Laboratory (NWML) to determine the need for temperature compensation on petroleum fuel deliveries to retail filling stations. In advance of the seminar NWML will be hosting on 11 March and to complete our draft report, we would like to receive some formalized responses from both trade associations and other interested parties. In addition, replies from individual members of the organization will be welcomed if you would be willing to circulate this request to them.

The points we would particularly like you to address are set out below. We intend to incorporate formal responses in our report and would therefore appreciate it if you could limit yourself to two pages. Feel free to provide as much supporting information as you wish to make us fully aware of your views. Since the case for and against introduction seems to attract entrenched positions, we must be able to reflect your acceptance of the problem and include your proposals on how compensation could be economically introduced and/or alternative means of visibly correcting the apparent measurement discrepancies that can be introduced.

NWML will host a seminar on this issue on 11 March at NWML where our draft report will be presented for comment. If you and/or your members are interested in attending you should contact NWML for an invitation.

As mentioned above there are several points that we feel it is vital that you cover in your formal response, namely:

i. Approximate quantities of fuel sold identifying each grade separately.
ii. Any practice involving allowances currently made to retailers for delivery of warm fuel; give details.
iii. As most terminals already have the equipment to allow compensation, what extra equipment would be required and at what cost.
iv. The economic case for temperature compensation.
v. The economic case against temperature compensation.
vi. If compensation or control were to be mandated, what would be the preferred technical method and why.
vii. Details of any studies that have been carried out into the issue of warm fuel deliveries; copies of reports would be appreciated if possible.
viii. If compensation were to be introduced as a legal requirement what would be an acceptable timescale for compliance before it became mandatory.
ix. Details of any studies you have carried out into the influence of vapour recovery systems on wet stock losses.

Any information other than the formal two-page organization reply, will be treated in the strictest confidence and individual sources will not be identified in the seminar or in any subsequent report without express permission.

To allow us to collate information and prepare papers for the seminar I would be grateful if you could respond by Wednesday 10 February. Faxed replies should be sent to my direct fax 01355 272536, alternatively you can e-mail me on dboam@nel.uk.

A P P E N D I X I V

FORMAL RESPONSES

FORMAL REPLY FROM UKPIA - Dated 10 February 1999

WARM FUEL DELIVERIES TO FILLING STATIONS

Thank you for your letter dated 27 January referring to the seminar NWML are to host on 11 March and requesting a formal response to specific points set out therein.

UKPIA welcomes the opportunity to re-emphasize our serious concerns surrounding any proposed changes to current Weights and Measures legislation as expressed in our letter to the Under Secretary of State in June 1997 (copy attached).

Mandatory temperature compensation measures, which may effect retailers in a positive or negative manner, will be costly and time consuming for an industry operating in an extremely competitive market and against a background of negative returns on investment.

The size of the "pie" available to be shared between wholesaler and retailer has been in decline for several years. Indeed the Office of Fair Trading in its report 'Competition in the supply of petrol in the UK' (May 1998) refers to "… petrol prices falling in real terms (minus tax and duty) by about a third since 1990 …". An inevitable result of across the board prescriptive changes to existing product measurement legislation will be the removal of another slice from this shrinking pie.

UKPIA would also challenge how such a regime fits with the Better Regulation Guide (Cabinet Office Better Regulation Unit) especially when referring to the principles of Targeting and Proportionality. It is, therefore, our firm belief that this issue is best left to competitive market forces.

As requested your letter has been forwarded to UKPIA members who may wish to respond individually to the specific points raised.

Signed by Chris Hunt
Company Secretary

COPY OF LETTER FROM UKPIA TO Mr Nigel Griffiths MP - dated 18 June 1997

PROPOSED CHANGES TO WEIGHTS AND MEASURES LEGISLATION PUT FORWARD BY THE PETROL RETAILERS ASSOCIATION

The UK Petroleum Industry Association (UKPIA) represents the interests of the oil refining and marketing companies in the UK. Our 13 member companies (BP, Conoco, Elf, Esso, Fina, Gulf, Kuwait, Mobil, Murco, Phillips, Shell, Texaco and Total) operate all the 11 major UK oil refineries and over 10,000 of the total 14,000 service stations are operated and/or branded by UKPIA members, who in total employ 17,700 people in these activities.

UKPIA has been informed by the Petrol Retailers Association (PRA), that it intends to lobby the Government for changes in current Weights and Measures Legislation, namely to propose amendments to The Measuring Equipment (Liquid Fuel Delivered from Road Tanker) Regulations 1983 and The Weights and Measures (Liquid Fuel Carried by Road Tanker) Order 1985.

The reasoning behind the PRA initiative is that it perceives its members are being financially prejudiced by oil company commercial practices, principally in the areas of measurement and temperature variations of petroleum products purchased by retailers. As a responsible industry operating in a fiercely competitive marketplace UKPIA members refute the need for any legislative amendments and contend the inferences made in the PRA Consultation Draft to sharp practice by oil companies.

Without wishing to respond to the PRA document line by line, the following observations are made on behalf of our members on the two key issues:

Measurement of Product

The PRA is concerned that oil company gantry meters at terminals are the sole source of volume data used for financial transactions. Conversely it is also stated in the PRA document that these meters are measuring fuel to a level of accuracy that “greatly exceeds that of the dipstick on the road tanker”.

Oil companies take stringent measures to ensure gantry meters are accurate. The same meters provide the basis for deliveries to oil company owned and operated service stations, which share the independent retailers’ obligation to maintain accurate records of fuel delivery, storage and product losses for petroleum legislation and environmental purposes. It is, therefore, not in UKPIA members interests, neither commercially nor morally, to adjust gantry meters to the detriment of internal or external customers.

Apart from this consideration, an conscious decision to under dispense product would be subject to consumer protection legislation and render any offending oil company liable to prosecution - a situation that would be totally unacceptable to UKPIA members. Furthermore, good management practice at service station level (monitoring storage tank ullage before and after delivery by dipstick or electronic tank gauging) will verify delivered volume.

Any move towards the incorporation of meters onto Road Tankers as suggested by the PRA will have three detrimental effects:

1 Truck weights will increase (meter plus product retained as meter primer of necessity) leading to increased distribution costs which will inevitably be reflected in the overall economics and have additional environmental effects through increased fuel usage in delivery fleets.

2 Truck meters will require calibration and verification by Trading Standards Officers. This is an administrative burden and cost for the enforcement agency and will inevitably result in delivery fleet downtime to carry out joint inspections. As such, any requirement for truck meters would be against oil company progress towards fleet optimization to contain costs and remain competitive.

3 The capital cost of meter installation, servicing and calibration will have to be met with the inevitable knock-on effects for other investment allocation.

Indeed, such is the impact of increased weight and cost of meters that German delivery contractors have ceased to install such equipment on tankers for over two years (and contrary to PRA statements). Further, the key issues of product losses through over dispensing to the motorist at the pump and leakage from underground pipework and tanks cannot be identified and then simply disregarded as they have in the PRA document.

Standard Temperature Adjustments

Attempting to compensate systematically for product temperature will be a costly and labour intensive process. Instrumentation will need to be installed, and readings taken, at the terminal and service station. Additional costs will then be incurred in the accounting process and how the whole system can be policed is quite unclear. Due to the competitive nature of supply to independent retailers many companies have temperature compensation built into their supply contract economic models or deal with the issue by additional allowances to the retailer. This reflects normal good commercial practice.

Conclusion

UKPIA represents a responsible industry acting in a responsible way. Whilst always open and receptive to commercially viable legislative changes aimed at improving our marketplace, we cannot support the PRA initiative on the grounds of either cost or need. Member companies should continue to deal with the issues of measurement and product temperature using sound commercial judgement to the satisfaction of both retailer and supplier, in preference to unnecessary legislation.

Signed by Dr Michael Frend
Director General

FORMAL LETTER FROM INDEPENDENT TANK STORAGE ASSOCIATION - Dated 3 February 1999

WARM FUEL DELIVERIES TO FILLING STATIONS

In response to your recent letter regarding warm fuel deliveries, please note our comments as follows:

We do not own the product, we load to road vehicles and therefore do not provide allowances for warm deliveries.

Not all terminals are equipped with loading meters fitted with temperature compensation. Essentially, such provision is linked to the timing of VOC legislation currently taking effect, but which is dependent on motor spirit volumes at each location. There are still terminals handling less than 25000 tonnes per year which are likely to continue until 2004 without bottom loading equipment and vapour recovery. These terminals may therefore be fitted with older metering equipment which does not include temperature compensation. Typically, as equipment is upgraded to meet the requirements of the VOC legislation, meters will be fitted which will normally have temperature compensation fitted.

If temperature compensation were to be mandatory, the date should therefore be not before 1 January 2004.

However, an important point to note, based on our experience, is that even if loading is carried out using temperature compensated meters, and even if the documentation which travels with the road tanker states bulk litres and standard litres (at 15ºC), when the road tanker arrives at the retail filling station, the road tanker is physically dipped by a filling station representative. If there is a shortfall in the bulk quantity recorded on the dipstick, which may be due to shrinkage, the representative will typically only accept receipt of a quantity to the next lowest graduation mark on the dipstick. An almost inevitable cause of such shrinkage is when product is loaded in the evening and then left overnight in the vehicle prior to delivery the following morning. As many dipsticks are graduated in 100 litre divisions, the acceptance of a lower quantity may result in say 90 litres off loaded into the filling station tanks which has not been accepted by the station representative. In practice of course he can only deliver to his customers the bulk quantities he receives.

Signed by M J A Lyons
Operations Manager, Bulk Liquids Division, Simon Storage

FORMAL RESPONSE FROM THE PRA

Thank you for your letter dated 27 January 1999 requesting submissions on the warm fuel issue from both the PRA and individual petrol retailers. You will, I am sure, appreciate that it is not possible to communicate with all our members at such short notice though a few may be able to respond by the deadline given. I take it that you have been given all the documentation included with our submission to the Minister on this issue but am including this as Attachment I for completeness. The latter document sets out the PRA's case. What I shall do in this letter is to emphasize the manifest unfairness which has evolved in both oil company practices and legislation which is to the obvious commercial detriment of the small petrol retailer and the cumulative advantage of the large oil supplier.

It hardly needs repeating that, in the final analysis, the purpose of legislation is to protect the weak against the strong, and that applies in this particular case. It is for this reason that the PRA is seeking changes in legislation. There are several threads intertwined in the warm fuel issue. The starting point is that, under their terms and conditions of supply, the oil companies reserve the right of measurement of volume being delivered (Attachment I). I enclose as Attachment II exchanges of correspondence with the Department of Trade and Industry on this subject. In this context, it is evident that trading standards authorities do not have the resources to challenge volume measurements at terminal gantry meters neither do these authorities believe they have the right to do so. This is illustrated by the letter for Cheshire Trading Standards in Attachment I and also in Attachments III and IV - letters from Trafford Metropolitan Borough Council and South Glamorgan Trading Standards on this issue. Therefore, it is not practically or legally possible for enforcement authorities to intervene on the petrol retailer's behalf so they are not prepared to do so.

The national stock loss survey and thermal imaging exercise carried out by the PRA and reported in Attachment I amply illustrates the existence of source terminal linkages with the extent of petrol retailer stock losses. The raw data from the survey is available if you wish to inspect it. Clearly, warm fuel sources are not static, they are erratic. Now, for example, we are having an increased level of complaints of stock losses from Scottish retailers. You will also be aware from Attachment I that the warm fuel issue often becomes apparent to retailers when the delivering terminal is changed. I enclose as Attachment V Mr Williams correspondence on this point along with a letter from Mr Lawrence addressed to me in response to your enquiry which makes the same point.

As Attachment VI, I enclose from the files two typical sets of correspondence from our members to supplying oil companies on stock losses.

More recently the issue has been exacerbated by the introduction of Stage I vapour recovery. Many of our members have paid to install the recovery equipment, as required by legislation. By doing so they have invested to create a new asset, the petrol vapour /condensate which would otherwise have been lost to atmosphere as stock loss. Oil companies have made no attempt to credit our members with the value of the returned vapour but do so for supermarket chains with more muscle. You will appreciate that the warmer the delivered petrol the greater the amount of vapour and condensate recovered from the retailer via Stage I. There is, therefore, an even greater economic incentive for oil suppliers to deliver warm fuel. The so called 'allowances' to retailers for stock losses are illusory.

The petrol retailer has no evidence that any allowance is made or, that if it is, all oil companies apply the same 'allowance', or even different allowances from different delivery

terminals. The only reality which the petrol retailer sees is the price paid per litre for supplies, any invoiced rebates which might apply and the stock losses incurred. How oil suppliers say they build up a price is irrelevant to how the petrol retailer manages his stock control and is nothing more than a smoke screen behind which suppliers hide when the issue of stock loss is raised. The whole purpose of the PRA activity in this area is to bring the issues out into the open so that oil companies have to operate in a transparent manner; hence the requirement to change Weights and Measures legislation. At present, the latter takes no account of fuel temperature other than to disallow measures intended to avoid fraud if the fuel is at other than ambient temperature. Which is astonishing in itself. As detailed in the PRA's submission to the Minister, both temperature compensation and control are required. Volume correction to ambient temperature is a simple instrumental and software exercise, as is the recording of this information on delivery notes and tanker loading notes. This will suffice for diesel fuel. However, it does not, on its own, prevent high stock loss by vapour/condensate displacement either to the delivering tanker, or to atmosphere. The only way to achieve this is by a limitation on the actual temperature excess of the fuel over ambient. There are, in any case, sound environmental reasons for limiting petrol delivery temperature. Temperature correction of volume should be possible within three months and control of product temperature within six months of any legislation coming into force as equipment to cool fuels on rundown is in place at refineries. The visual observation of condensate in the vapour return pipe to the tanker indicates that supersaturated vapour is being passed from the underground tank. Since STP volume displacement of vapour accounts for a 0.18 % volume stock loss, according to DETR figures, we can be sure that non-equilibrium conditions, turbulence, butane content and above ambient temperatures would increase the amount of vapour transferred to significantly above this level. That is in addition to the thermal contraction-related losses.

The PRA has calculated that, on a conservative basis, some £50 million per annum is lost by petrol retailers as a result of warm fuel deliveries. This is not evenly distributed but is suffered to the greatest extent by retailers fed from refinery terminals. It amounts to many thousands of pounds per year for affected retailers and has contributed to many going out of business.

Please let me know if you wish to explore these points in greater detail.

Yours sincerely

Peter L Barlow
Environment, Health and Safety Adviser

FORMAL RESPONSE LETTER FROM LACOTS - Dated 1 March 1999

"Shrinkage" of Liquid Fuels

Further to my letter identifying those authorities willing to assist or provide information to your project, I would wish to set out LACOTS' position concerning the matter.

Local trading standards authorities are not unfamiliar with complaints concerning apparent stock losses attributed to temperature variation. The authorities exercise their regulatory responsibilities in this difficult area, in particular their duties under the Weights and Measures Act 1985 and the Trade Descriptions Act 1968. Additionally, authorities have a wish to see legal and trading clarity for businesses, both small and large, who are involved in the distribution of petrol throughout the chain.

LACOTS' concern to see a resolution of the present "uncertain" position has been manifested in our support for NWML commissioning the study now being undertaken.

Yours sincerely

R J Diplock (ext.27)
Secretariat - Legal Metrology
e-mail:metrology@lacots.org.uk

FORMAL RESPONSE FROM AUKOI - Dated 3 March 1999

Thank you for the opportunity to comment on your study examining the background concerning hot deliveries. I have been reviewing the matter with our Members and have some comments that I would like to pass on to you. I am not in a position to answer all the questions you have posed but they have formed the basis of the deliberations of AUKOI Members. I hope you will find that these points are helpful and that you will consider them fully before recommending any action to NWML.

PRA Studies

We have studied the research of the PRA concerning the incidence and distribution of hot deliveries. We accept that the temperature of deliveries does vary around the country and some supply points are generally of higher temperature than others. Our Members conduct internal monitoring and have no reason to dispute the findings of the PRA and their advisors.

Members Negotiations

Our Members have for many years monitored the temperature of deliveries made to them from differing supply points. Armed with this knowledge they then make sure that in negotiations over price with the supplier that potential temperature losses are taken into account. Our Members find that this is an effective way of solving the problem. Such a commercial solution avoids the need for any expensive additional equipment, the testing and recording of individual deliveries for temperature and relevant adjustments and (if meters on tankers are required) this would require a pressurized or pumped system to operate effectively with a consequent loss of payload.

General Solutions

You asked for commercial as well as technical solutions to the distortions of high temperature deliveries. We believe there is a solution based on the procedures described above of our Members, which is successfully in practice at present. For smaller companies contracting for/buying petrol the same commercial solution would work. The PRA have been collecting the data of what the temperatures generally are. Their Members (retail company buyers) need this on a more consistent basis from suppliers and the suppliers should be encouraged to provide this information on an averaging basis - say for each month of deliveries - so that the expected temperature effects of ambient vs delivered can be taken into account. When prices are negotiated then this can be a factor in the negotiation.

PRA Monitoring

The efforts of the PRA in monitoring temperatures is the root of the solution to the problem. Now that it is known that the temperature of deliveries does vary and may well be above ambient at some times of the year, then it is possible for the PRA to continue with its work to ensure that all its Members are fully appraised of the likely temperatures for different supply points. Armed with this information, PRA petrol stations can then negotiate with their suppliers to take account of this in their price negotiation.

Industry Practice

The oil industry generally has to live with a rather inexact system as regards measurements. The accuracy of measurements are limited because of the differing types of equipment used and the inherent inaccuracy of dip-sticks and the temperature adjustments required with fluctuating ambient temperatures. Furthermore there is different equipment used in different areas giving slightly different results. Water content and sampling causes more potential distortions. Therefore the oil industry generally uses the commercial methods of allowing for these variabilities. In marine insurance the first 0.5% of losses is disallowed and companies allow for this when transporting fuels. They also know there is a more general loss factor for marine shipping of 0.3% which is also taken into account. The commercial solution operated by our Members in the retail market is similarly based on experience factors. The cause of the inaccuracies are different but the solution can be the same.

HMC&E

HMC&E have recently announced general factors whereby losses will be allowed in various sectors of the industry. In tanks they are to allow up to 0.3% for storage tanks per month and maybe up to 0.4% for tanks without floating roofs. In pipelines different allowances will be agreed. If losses are below these thresholds they will be accepted without further explanation and above additional explanation will be required. This again serves to illustrate the general loss experience caused by various factors in the industry and Govt recognition of this. The principle of generality is important in seeking to accommodate inherent factors of the trade without requiring additional equipment and monitoring and the expense that this causes.

(Additional note provided by NEL.: C&E have provided a correction to the above statements pointing out that while recognising that natural losses of product occur, the percentage figures quoted above are for guidance only and are assessed on a site by site basis. The agreed loss figures allowed may be greater or less than the guidance figures for any particular installation.)

Markets

The domestic retail market for petrol is like any other market. There are different prices being offered both under contracts and for spot deliveries and the customer can compare prices in a free market. The prices will all have elements of difference in them. There will be different associated transport costs dependent on the supply route of the seller and buyer. There is the size of the parcels to be delivered and the number of grades as well as the type of contract and the relationship, if any, between seller and buyer. The temperature is just another factor to take into account.

Technical Solutions

Metering of deliveries with temperature adjustment to ambient temperature will cause added expense and operational complexity which is not justified by the benefits. If the meters are on board road tankers this will reduce payload and increase costs. The consumer will inevitably pay or the hard-pressed industry will have its margins eroded further - there is no alternative. Again there is no justification for this. The motorist is already burdened with excessive excise duty (and VAT) payments and unnecessary expense for the supply industry will only add to costs.

Conclusion

There is no justification for a change to current practices except for more temperature information to be made available to petrol retail buyers. Perhaps a code of practice could be agreed for disseminating this information. Metering with temperature adjustment would require pressurized or pumped systems which would be costly and the consumer would pay. A commercial solution is an efficient use of markets and serves the need.

We urge you to consider our comments and thank you again for the opportunity to make them.

Signed by M I Annesley
AUKOI Secretariat

FORMAL REPONSE FROM THE INSTITUTE OF TRADING STANDARDS ADMINISTRATION

WARM FUEL DELIVERED TO FILLING STATIONS

Thank you for extending to this Institute an opportunity to submit a formal response in connection with the NEL study. The Institute of Trading Standards Administration is the professional body, which represents the interests of Trading Standards Officers, and, as such, has no direct involvement in the distribution or sale of fuel. We are therefore unable to comment against most of the points listed in your letter, and what follows can only represent generalized comments from our perspective.

This particular issue is well known, and has been so for a number of years. The Trading Standards service regularly receives small numbers of complaints about 'short measure' fuel deliveries to filling stations, but these are sufficient to lead us to believe that there is a problem, although for reasons that I will come to, it is impossible to either quantify it, or to say how widespread the practice may be. Anecdotal evidence tends to suggest that the practice may be limited to a number of refineries.

The law governing sales of this type is effectively unenforceable. The only legal control over gantry meters is Section 17 of the Weights and Measures Act 1985, which requires equipment in use for trade not to be "false or unjust". Unlike retail fuel dispensers (which are "prescribed" for the purposes of Section 11 of the Act, and so have associated limits of error set in Regulations), the law remains silent on what is "false or unjust". In the writers view, if a case was to be taken alleging that a gantry meter was "false or unjust", such a case would probably fail unless any error was greatly in excess of the sorts of errors permitted for "in service" use of different types of "prescribed" instruments. We would probably have to be looking at errors in excess of 1 or 2%, which I suspect is well in excess of any errors that are likely to be encountered in practice.

The Weights and Measures (Liquid Fuel delivered by Road Tankers) Regulations 1983 does prescribe dipstick measuring systems on road tankers where these are used for trade. In practice, changes in Health and Safety legislation and practice now make it impossible to use such systems.

Section 28 of the Act creates a general offence of "delivering a lesser quantity than purported to be sold". Leaving aside the issue of any contract conditions which might state that the quantity sold is determined at the time of loading, the provision is, again in this writer's view, practicably impossible to enforce. There would be two possibilities. In the first instance a delivery could be intercepted and measured at the point of transfer between the tanker and forecourt storage. The second option would be to ascertain the quantity of fuel in storage immediately before, and immediately after, delivery.

So far as I am aware, there is no method that can be used to measure fuel during the delivery 'drop' for the simple reason that any meter used would have to be properly primed (ie on a "full hose" system), whereas the 'drop' is made via a "dry hose". Even if some means could be devised to overcome this problem I suspect there would be grave Health and Safety reservations surrounding the practicalities.

The second option is even more problematic. The individual storage tank would have to be calibrated (at no small expense) and, most importantly the issue of possible leakage will have to be adequately addressed. The tank would have to be "quarantined", for the

duration of the exercise, which might well be unacceptable to the retailer. Even if all these issues were to be addressed, there would still be the associated (and unquantifiable factors) relating to vapour loss.

To be successful, any prosecution would have to be proved “beyond any reasonable doubt”. The nature of the product in this case simply leaves too much opportunity for a defendant to cast doubt on the accuracy of the measurement, and the moment that doubt arises in the minds of the court the case will fall.

It is for these reasons, and these reasons alone, that the Trading Standards service has been unable to take action against the practices alleged. We understand the position of the retailers, and indeed have sympathy with them. We understand that the oil industry apparently has no difficulty with applying standard temperature corrections for bulk transfers for its own purposes, and it is difficult to see why it should not be able to apply the same principles to tanker deliveries. However, one corollary of this would be that the same principle could equally be applied to retail sales. With modern dispensers and the virtual disappearance of mechanical indicators, it would seem that the incorporation of a temperature sensor and a software correction applied to the meter output is technically feasible and probably practical at no great cost.

Finally, there is one further aspect of this subject that gives cause for concern. I have noted that there are relatively few complaints in number. In part this is probably due to the fact that the retail sector recognizes that there is little that Trading Standards Officer can do (for whatever reason). It is also known that a number of “complaints” could never have been pursued in any event, as they were made “anonymously” - the complainant having allegedly been threatened with loss of supplies if he or she complained to regulatory bodies. Again, it must be stressed that this is anecdotal - given the nature of the allegations they are effectively incapable of proof, but they are sufficiently common to make many inspectors believe that there is likely to be some truth in them.

I hope these observations will be of some assistance to you,

G.C. Howell
Lead Officer, Legal Metrology

A P P E N D I X V

REQUEST FOR LOADING DATA

Urgent FAX back to Mr Denis Boam 01355 272 536

Temperature Compensation of Petroleum Fuel Deliveries

All data supplied on this form or in any follow-up will be treated in the strictest confidence and individual sources will not be identifiable in any report or presentation

Depot address:	Product	
Manager: Tel: Fax: email:	Diesel	Premium unleaded gasoline
Quantity of product dispensed per annum.		
Source of fuel - refinery, sea, rail, pipe etc.		
On-site storage capacity.		
Approximate time in storage.		
Pressure at loading meter (bar).		
Is delivered temperature measured?		
Is temperature recorded at each loading meter?		
Is each individual delivery temperature recorded?		
Mean temperature at meter ºC.		
Normal operating range of temperatures high/low ºC.		
Annual extremes of temperature at meter high/low ºC.		
Do temperatures at meters show seasonal fluctuations? If so please give details.		
Is volume dispensed compensated for temperature for other purposes? e.g. interval stock control or excise duty. Please give details.		
What area is covered by road tanker delivery from depot? (approx. radius miles).		
What vapour recovery measures are in place and when were they installed?		
Details of recorded complaints of 'hot' deliveries.		
What retail brands are supplied from this depot?		

Thank you for your co-operation, please return this form to Mr D Boam

A P P E N D I X V I

TEMPERATURE COMPENSATION OF LIQUID FUELS SEMINAR - 11 March 1999 -- ATTENDANCE LIST

Name	Company
Richard Paton	NEL
Denis Boam	NEL
Bill Cunningham	Fuel Management Services
Peter L Barlow	Petrol Retailers Assoc.
Richard Danisz	Save Service Stations
James D Snook	IP Petroleum Measurement Committee
A J Thorogood	IP Petroleum Measurement Committee
J Miles	IP Petroleum Measurement Committee
Yash Kadan	Kuwait Petroleum (GB) Ltd
D M Nichols	Shell UK Ltd
Tom Ramsey	Esso
M Watson	UK PIA
Tony Booth	West Yorks TS
Dick Diplock	LACOTS
Andy Watson	South Glos Council
Chris Howell	ITSA
Stephen Downes	NPL
Peter Badger	NWML
Mich Koch	NWML
Elwyn Williams	NWML
Chris Rosenberg	NWML
Mike Fortune	NWML
Christine Munteanu	NWML
Pat Brennan	C&E
Ruth Lyons	DTI Legal AI