Ergonomic and Dimensional Review of Liquid Fuel Measures

Liquid fuel measures are the most frequently used instruments for legal metrology worldwide. External developments in increased fuel dispenser flow rates and concern for occupational health hazards for operators have dictated another design review of the measure.

The resulting improved ergonomics allow the safe use of larger capacity measures and raise fundamental questions as to the appropriate size of samples for inspection and verification of dispensers and the validity of minimum delivery and slow flow rate tests. Are the use of 2, 5 and 10 litre measures, minimum delivery and slow rate tests relevant to the typical use of fuel dispensers and to consumer protection?

Current Practice of Testing

The detail of regulations governing inspection and verification of liquid fuel dispensers varies considerably between jurisdictions. National regulations and local procedures interpret OIML recommendations differently, and in so doing they frequently reflect long established local practices, and even the historic presence of old small copper measures. However, whether the testing is by the officers of a unitary national metrology authority, or by local or regional bodies, or by accredited commercial service companies, internationally the actual physical process at the fuel dispensers/pumps is fundamentally identical. A sample volume as registered by the meter is dispensed into a liquid volume measure of fixed volume capacity, the variation is observed, the fuel sample is returned to the tank from which it came, and an adjustment made to the meter, if necessary. Despite the universality of the service station phenomenon, the size of vehicles, the performance of dispensers, etc, a surprising lack of uniformity exists in national regulations for testing dispensers in use.

Integrated Measures

It is difficult to minimise systematic and random errors in the measurement process, particularly when one recognises how variable and even hostile the environment at the service station can be, compared with the environment of the laboratory or factory at which the measures were calibrated.

The two largest absolute errors were addressed in the first fundamental redesign of the liquid fuel volume measure (OIML Bulletin, Vol XXXVI, No. 3 April 95), and the resultant “PUMPWATCH Integrated Measure” eliminated the systematic temperature error by automatic temperature correction and minimised the random observer error by greatly increased resolution in an integrated tall parallel measurement tube fed from the narrow neck of the measure.

Simultaneously, the ergonomics of the testing process were addressed and the 20 litre integrated measure was made transportable on wheels across the service station to the tank fill pipe.

Need for a Revised Design

As part of a compliance process of obtaining approval for the use of the “PUMPWATCH Integrated Measure” from statutory national metrology authorities in a number of countries, valuable international feedback has prompted another comprehensive design review. This has resulted in a much improved measure, manufactured to a simpler design but of a more sophisticated construction material, and the ergonomics of its use have received much greater attention. The choice of a new construction material is at the core of the redesign.

Carbon Epoxy Material

Instead of stainless steel, carbon fibre epoxy composite was selected as the new material, not just for its high strength to weight ratio but principally for its exceptional thermal dimensional stability. When a carbon fibre epoxy composite has a sufficiently high fibre content, ca. 50%, so that the properties of the resultant composite material can be described as “fibre-dominated”, the thermal expansion or contraction is so small as to be described as “within measurement uncertainties”, i.e. at least ten times less than stainless steel. This thermal stability property makes carbon fibre epoxy composite the preferred material for the structure of artificial satellites which are required to be dimensionally stable when oscillating between full solar radiation and the near absolute zero temperature of space in the shade of the Earth. Carbon fibre epoxy is also well known in many high performance consumer products such as fishing rods, golf clubs and tennis rackets. Epoxy coatings are well established for fuel storage tanks and have been specified for mild steel liquid fuel measures. Because of the high carbon content, the carbon epoxy composite is also electrically conductive and has been found to be satisfactory in tests for static electricity.

Improved Ergonomics and Bottom Discharge

Feedback from users of the earlier stainless steel integrated measure pointed to the need to improve the ergonomics. The first PUMPWATCH integrated design with wheels was already a major step forward in avoiding the lifting and carrying of 20 litre measures weighing approximately 20kg across a forecourt. Discharging into some tank fill pipes posed new demands. Many tank fill pipes are now up to 500mm overground instead of in a manhole. They are so placed in order to make it easier to connect the delivery hoses from tanker lorries and they are usually capped with a 45^{o} bend. This configuration has caused problems by requiring the lifting of all measures, including traditional ones,

to discharge them, and a conventional funnel will tend to fall out of such a fill pipe.

Manual Handling Issues

The importance of ergonomic design was reinforced by several other developments. The European Union's Manual Handling Directive 90/269/EC applies throughout the Union since 1995. In summary it states that no manual handling of heavy loads is permitted and equipment must be provided to avoid the need for manual handling. In Europe and in other jurisdictions, litigation for occupational injury claims from operators has highlighted the need to eliminate the traditional practice of carrying and lifting 20 litre measures, even if it is only for emptying. Another significant development is the increasing presence of female inspectors which reinforces the need to avoid imposing demands on operators to carry heavy loads. The new PUMPWATCH CFX Integrated Measure eliminates such demands at all stages of the test procedure.

Success in Compliance/Approval Process

The second phase of close liaison with statutory national metrology authorities has resulted in the new PUMPWATCH CFX becoming approved for use in 32 countries world-wide including Ireland, UK, Germany, Belgium, the Netherlands and Slovenia. In some jurisdictions statutory regulations had to be formally amended to permit the use of the carbon fibre epoxy integrated measure. In parallel with winning the respect of calibration metrologists for the unique features which address the instrument and operator errors, the new measures in use by the legal verification and inspection officers have been welcomed most especially for their user friendliness. It is hoped that the ongoing process of obtaining international acceptance as an industry standard may be accelerated by the national approvals already secured. This process has also raised the following issues for consideration by practitioners of legal metrology worldwide.

Consequences of Revised Design for Legal Metrology

Taken together, reduced or eliminated measurement errors, lighter weight and much improved ergonomics may be regarded simply as long overdue technical enhancements of this legal metrology instrument. But if we consider the ultimate objective of their use, the availability of such lightweight and ergonomic measures can challenge some standard procedures in the inspection and verification of dispensers in use. We may postulate that as far as practicable, a fundamental principle of legal metrology is that a dispenser should be tested as it is used for trade. If we accept this, and indeed it may be impossible to point to examples from other fields of legal metrology where this rule does not apply, then we should ask how are fuel dispensers typically and routinely used in trade by pump attendants or, far more commonly, by the consumer?

OIML International Recommendations R118 and R120

While recognising that OIML R120 applies to pattern approval, this recommendation and OIML R118 make frequent references to flow rates and the testing of fuel dispensers at maximum flow rate for a minimum of 1 minute, or even two minutes (R120, clause 4.5). These recommendations make only

one reference to the necessary size of the measure for such tests, 50 litres, (R118, clause 4.1), but since even petrol dispensers may operate at 45 litres/min, one may question how 20 litre measures meet these recommendations? Significantly, R120 clause 4.5.3, specifically states that “It is recommended that at all flow rates, the test time should never be less than one minute.” This recommendation alone, if universally applied in all regulations, could prohibit the use of measures less than 50 litres.

Conclusions

The re-design of the PUMPWATCH CFX Integrated Measure has resulted in the development of an integrated ergonomic trolley for practical, lightweight and safe 20 and 50 litre measures. The international experience of the designers with a number of national legal metrology authorities has suggested that the choice of size of sample volume in testing should be determined less by tradition and more by that which is truly representative of their typical usage.

Accordingly, to bring the testing of dispensers in use into conformity with consumers use, it is suggested that national regulations and procedures and OIML International Recommendations, could address the following proposals:

1. Permit and recommend the sole use of 20 litre measures (or larger) for petrol dispensers, and 50 litres (or larger) for diesel dispensers (in excess of 100 litres/min) for all testing of dispensers in use.

2. Review whether minimum delivery (2 litres) and slow rate tests should continue to be required.

3. To the extent that small measures may continue to be used, e.g. for minimum delivery, apply a lesser “weighting” to such tests as compared with parallel tests with measures sized appropriately to the normal flow rate.

4. Address Uniformity of interpretation and application of OIML International Recommendations in national regulations and procedures governing fuel dispenser inspection and verification.

While such proposals may have been rejected in the past because practical instruments to carry out such representative tests safely, accurately and efficiently did not exist, with the development of PUMPWATCH CFX 20 and 50, such arguments may now be valid.

Observation and common sense tells us that the overwhelming majority of all fuel dispensed is pumped from dispensers at the maximum flow rate. Petrol pumps typically operate at 35 to 45 litres/min and diesel pumps at 50 to 60, and increasingly at 120 litres/min. These flow rates are dictated by concern for the safety of self service operators but also by the standard size of a fuel tank in a vehicle, typically 50 – 70 litres in cars and up to 1000 litres in heavy goods vehicles. Thus an average purchase of petrol for a car is approximately 20 to 50 litres, and for a heavy goods vehicle 200 to 800 litres of diesel, and it is hard to imagine that anyone would deliberately take longer than absolutely necessary for this operation by using a slow flow rate, for whatever reason.

Only those filling a small motor bike, moped or scooter will fill their tank at anything other than the

maximum flow rate. Only a motorist whose vehicle has run out of fuel and who has to fill a portable can will dispense an amount close to the minimum delivery of 2 litres. If these modes of operation are demonstrably unrepresentative, we should ask what substantive consumer protection is provided by testing into small volume measures and/or at slow flow rates?

Hal Sisk, Inventor and Sailing Historian, designed and developed the world’s first carbon fibre test measure in 1999 as a solution to the ergonomic, low resolution and temperature issues relating to the then traditional stainless steel and copper test measures and visi-gauges. He continues to strive to improve the user experience and reduce operator errors during fuel dispenser accuracy testing.

