DEVELOPMENT OF A PLASTICS BODIED WATER METER FOR USE IN SOUTH AFRICA

Final Report to the

Water Research Commission

prepared by

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PREFACE

In March 1992, in terms of a Letter of Agreement, the Water Research Commission agreed to financially support Kent Measurement (Pty) Ltd, with the development of a plastics bodied water meter.

The broad objectives of the project were to:

- select and evaluate suitable materials and the development of a suitable meter product;
- design injection moulding dies and selection of moulding machines and a cost analysis;
- manufacture the injection moulding dies and manufacture trial batches;
- undertake accelerated laboratory tests at the SABS followed by field monitoring and durability trials.
- finally, bulk manufacture.

Kent Measurement (Pty) Ltd could also draw on its extensive international expertise and state-of-the-art technology.

The R&D Centre in Luton (UK) was utilized to develop the product and to fabricate and test the samples.

Injection moulding expertise was derived from vast experience and investments in the UK, Germany, Spain and Puerto Rico. The stress analysis was undertaken by the GEON Company, Application Engineering & Design Laboratory, Avon Lake, Ohio, USA.

ACKNOWLEDGEMENTS

The product described in this report emanates from a project partially funded by the Water Research Commission.

Kent Measurement (Pty) Ltd gratefully acknowledges the Water Research Commission for its support and encouragement during the various stages of the development and through to the successful conclusion of this product. In particular, Mr Piet E Odendaal, for authorizing the expenditure and Messrs David S van der Merwe and H Charles Chapman for promoting and running with the project since its inception.

Kent Measurement (Pty) Ltd would also like to acknowledge Mr Ronald Burle who initiated the project in his capacity as Managing Director until his tragic death in February 1993.

The assistance and support of our International sister group companies is sincerely appreciated.

Finally, Kent Measurement would like to express its appreciation to the members of the JASWIC Acceptance Committee who enthusiastically endorsed the need for a plastic bodied water meter and undertook to participate in the field evaluation of the product. Their guidance in aiding the design of the final product was invaluable.

Table of Contents

1. BACKGROUND

The provision of infrastructure in the form of water, sanitation and electricity for low cost housing schemes is a much needed priority in South Africa. In view of the limited funds available it is essential that the infrastructure cost per housing unit be kept to a minimum in order to service the maximum number of erven with these facilities.

The metering of all water supplies has been accepted as crucial to the good management of water.

The installed cost of water meters is one of the more prominent cost inputs which therefore requires attention.

A popular opinion voiced by many authorities in South Africa was that a cheaper, possibly plastic bodied water meter would be the ideal solution, also obviating the problem of theft for the scrap value of brass-bodied meters.

2. INTRODUCTION

For low income group housing, a major cost factor of a new domestic water meter is the cost of the brass body. This cost has a double component namely the actual cost of a new body as well as the cost incurred as a consequence of pilferage. Pilferage is a major cost factor in the South African mass housing environment in view of the intrinsic scrap value of the brass materials. This in turn has a demobilising effect on progress because local authorities are understandably unwilling to serve such areas.

The concept of using a disposable plastic body with no intrinsic material value hence deserves considerable merit in this particular type of environment.

The potential market in RSA alone could be as high as 3 to 5 million units.

2.1 Historical background

A number of meter manufacturers have, over the past 15 - 20 years, provided meters having plastic bodies.

The market share captured by such meters has however, to-date, been minimal, largely due to problems caused by structural/chemical failure of this type of body.

The inherent problem has been the mechanical/chemical stability of the plastics raw material under the many diverse installation conditions. Mechanical stress fractures, material creep, chemical leaching etc. after unspecified time periods made plastics materials less attractive to users than solid brass, where the likelihood of failure was thought to be minimal.

2.2 Considerations regarding materials selection

2.2.1 Growth in the Plastic Industry

Plastics materials today are far more refined and predictable in terms of their behaviour pattern under various conditions than was the case some years ago.

The number and variety of plastics materials available has multiplied.

Similarly, Injection Moulding Technology has made significant progress permitting a far better control over the moulding parameters such as temperature, pressure, interface bonding and time cycles, which critically influence the quality of the end product.

2.2.2 Lack of Industry Enthusiasm

Most manufacturers worldwide are reluctant to invest in tooling for plastics bodied meters in view of:

- The potential fear of long term failure;
- There has to-date been no major pressure on manufacturers to supply such a meter;
- The high investment cost in the form of new tooling/machinery -accompanied by obsolescence/under-utilization of existing equipment.

Today, most major companies offer plastics bodied meters in certain countries where the installation conditions and type of meters offered permit such installation. Again the quantities sold are small as users who are concerned about their long term metering costs are reluctant to sacrifice long term benefits in exchange for short term benefits i.e. a lower purchase price of a new meter.

2.2.3 Motivation for Plastics Bodied Meters in South Africa

The desirability for developing a plastic meter for South Africa can be supported by the peculiar conditions pertaining to this market, i.e.:

- the high market potential in the mass housing sector;
- the high cost of pilferage in this sector;
- progress made in plastics materials technology.

2.2.4 Concerns

Chlorine

Raw materials suppliers, both local and overseas (Germany), state that chlorine levels below 0,3 mg/ℓ are not critical. However, chlorine levels sometimes in excess of 1 mg/ℓ are encountered.

What was not established was the long term effect (if any) of a plug flow of high chlorine content ($\pm$ 3 mg/ℓ, during disinfection, etc) over a short period of a few hours, or even days. We are also not certain of the long term effects of anti-corrosion chemicals or fungi/algae-cides.

An accelerated test indicated that the attainable stress duration when ageing reduced from 50 000 hours in air to only 800 house in water containing 0,5 mg/ℓ chlorine - a factor of 60:1.

Temperature

The same suppliers indicated that temperatures over 30°C would seriously reduce the expected lifetime. This reduction would be further adversely impacted by increasing pressure and, as mentioned above, chlorine.

At a constant 10 MPa, results showed a decline from 50 years below 20°C to less than 1 year at 60°C.

Should temperatures escalate to as high as possibly 50°C even if only for very short periods, the service life reduces significantly. Pressures can also be momentarily higher due to solenoid operation (washing machines) and water hammer.

Ultra Violet (uv)

For plastics, uv is obviously a death knell. However, it is relatively simple to stabilize plastics against uv degradation, which is further alleviated if the meter is installed in a meter box.

Polycarbonate was found to "craze" under constant or cyclic pressure. Badger in the USA experienced serious body failures even when using glass loaded polycarbonate.

Thus the decision was made cease consideration of both acetal and polycarbonate and to rather concentrate on polyacetal which appeared to be resistant to both chlorine and higher temperatures. However, using this material was breaking new ground for Kent meters who had had no previous experience with this material.

3. PROJECT DESCRIPTION

The project involved the following major activities:

- selection/evaluation of suitable materials;
- development of a suitable meter product;
- design of injection moulding dies/selection of moulding machines.
- cost analysis;
- manufacture of injection moulding dies;
- manufacture and installation of trial batches;
- accelerated laboratory tests (SABS);
- field monitoring and durability trials;
- bulk manufacture.

4. STRESS ANALYSIS

The analysis was performed using IDEAS Level VI Mechanical Computer Aided Engineering software installed at the GEON Company's design engineering facility in Avon Lake, Ohio, USA.

Results of the analysis revealed potential for failure in the area of the counter housing. The flat face near the counter window hole also appeared as a high stress and deflection region. The stress was of concern since there is a weld line in the vicinity. One of the problems encountered with glass or fibre reinforced materials is that there is no continuity of the fibre across the weld line.

4.1 Possible Solutions

To overcome these problem stress areas, the designers thought it would be beneficial to increase the outside radius where the body meets the threaded spud end, since the majority of the loading is distributed to the remainder of the fitting through this transition zone. Increasing the radius allowed more stress to be distributed through the fitting instead of being concentrated near the radius.There are several areas where ribs and bosses intersect the main body. It is advisable to make radii at these intersections as large as possible in order to reduce stress concentrations, which enhances the notch sensitivity of the material.

4.2 Recommended Solutions

It was recommended that the highlighted changes to the gate geometry be considered for all materials. These changes reduced jetting of the material improving the overall strength of both parts.The strength and location of the weld line obviously affected the performance of the meter body under pressurization testing. Moving the weld line to either side of the counter window through the use of flow leaders in the part proved beneficial but did not necessarily eliminate the potential for failure under pressure testing. If these changes were not viable, consideration should be given to using a high strength, high heat unfilled vinyl material be used.

It was also recommended that the proposed part modifications be considered regardless of the material chosen in order to improve the overall quality of the housing components.

5. <u>DIE MANUFACTURE</u>

Robust injection modelling dies are extremely expensive items and for full production a number of sets would be required. To test the design of the system, which includes the plastics material flow characteristics, the moulding process, the actual die manufacturing procedure, and finally the finished product, cheaper aluminium moulds were initially produced for a limited prototype run of around 1000 samples for evaluation. This was completed during the latter half of 1994.

6. <u>PROTOTYPE</u>

Early prototypes (1992) were of acetal material, one plain acetal and three with various percentages of fibre additives (10, 20, 30%).

At that stage minimum burst tests were in excess of 3000 kPa (30 bar), although the plain Acetal (without any fibre additives) performed the best with a bust test of over 5000 kPa (50 bar). This was attributed to homogenous bonding across the weld line of the plain acetal material, whereas the fibre particles did not bind across the weld line in the other materials.

7. FINAL PRODUCT

In order to allow for comfortable radii on the junction of the stub ends with the meter body, the initial designs were for a meter body with an overall length of 165 mm. At the Steering Committee meeting held in Port Elizabeth on 5 November 1995 (JASWIC meeting) it was agreed that its overall length should conform to the I.S.O. dimension of 114 mm. This decision necessitated a change in the overall strategy of the project and rendered the prototype moulds obsolete. Thus, modifications were required to alleviate certain stress points that were inherent in the previous mouldings and flow characteristics of the injection process were enhanced by smoothing sharp bends with longer radii. These modifications resulted in a vastly improved product.

The availability of the cost-effective plastics bodied water meter coincided with the launch of the RDP plastic meter box at the Johannesburg Country Club, on 6 June 1995.

Subsequently, new dies have been commissioned to accommodate an 8 digit counter and a pulse facility. These dies will be sent to South Africa for local production of this unique water meter in accordance with our claim: "made by the people for the people".

8. CONCLUSIONS

Early indications are that the final product meets all the requirements of a robust plastics bodied water meter. The project has demonstrated how international conglomerates can join with South African initiatives and innovation to produce a world first.

9. RECOMMENDATIONS

The intention that the plastics bodied water meter be manufactured in South Africa and marketed throughout the world, needs to be aggressively pursued.

The suggestion by Mr PE Odendaal, Executive Director of the WRC, that a small handing over ceremony with the Minister of Water Affairs, Prof Kader Asmal, be held once the latest dies incorporating the pulse facility and an 8 digit counter are available, should be followed up.

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