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International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

The Development and use of Plastic Sacks for Fertilizers

By E. W. Schwehr (Fisons Fertilizers Ltd, United Kingdom)

1. Introduction

It is the object of this paper to set out the reasons for the comparatively extensive use in the United Kingdom of heavy duty plastic sacks for fertilizers and to report some of the early results obtained in experiments carried out by my Company.

2. Why Plastic Sacks?

In Britain, the accepted standard fertilizer package is a five or six ply paper sack incorporating a wet strength outer ply and two protective barrier plies. This sack performs excellently and withstands, mechanically, the general pattern of the trade, which includes not only filling and despatching, but handling through works stores, merchants stores, and farm storage before the fertilizer is used in the field. It is sealed by sewing or is of the valved type; in neither case is it, therefore, a hermetically sealed unit. Whilst providing adequate protection to the fertilizer in covered storage, it cannot prevent the ingress of moisture droplets or water vapour if stored in the open. Furthermore, the mechanical strength of paper is negligible when wet and is greatly reduced by repeated wetting and drying.

The development of plastic films in recent years has made possible the fabrication of water resistant sacks which can be filled with fertilizer and stored in the open. The economic advantages which can result from this are obvious. Such sacks do not require expensive storage buildings, and both merchant and farmer can take full advantage of early

delivery rebates. Fertilizer deliveries can, if required be made direct to the fields where they will be used and farm handling costs are reduced.

These are potential savings which can be achieved only if there is little or no difference in basic cost between a plastic and a paper sack, and if the performance of a plastic sack is in all respects acceptable.

3. Commercial Development

In 1961, marketing of fertilizers in polyvinylchloride (P.V.C.) sacks commenced in Italy, and in polyethylene (P.E.) sacks in America and Canada. In Britain, although paper was still considerably cheaper than plastics, the margin appeared to be decreasing progressively, and my Company decided to carry out large scale development and testing of plastic sacks. This work is still continuing.

4. Experimental Work

Heavy duty plastic sacks of 1 cwt. capacity supplied by a number of manufacturers have been used. The sacks have been fabricated from P.V.C. and P.E. films having varying characteristics and thickness.

Test work has involved the filling of these sacks on normal plant equipment; test groups have never been less than 500 sacks and often considerably more. Filled sacks have been subjected to the same operations as would occur in normal trading. Assessment has been based on operational performance at all stages, including transport by road and/or rail, together with an examination of the condition of the fertilizer at varying periods up to 12 months storage in the open on both prepared and unprepared sites. These tests have been supplemented by laboratory characterisation of the films used and re-examination of exposed sacks.

The work is reported, not in chronological order of the tests, but as separate assessments of individual problems, although any one trial necessarily included

investigation of many variables.

To date, the investigations have involved the filling, sealing and stacking of approximately 50,000 sacks.

4.1 Type and formulation of plastic film

The temperature range over which a P.V.C. sack can be used will be controlled by the type and quantity of plasticiser added to the polymer before extrusion. Sufficient plasticiser must be added to prevent embrittlement at winter temperatures, whereas too much will give a sack which is soft, easily distorted and stretched at summer temperatures. For any one type of plasticiser there is a limited effective operating temperature range which can be moved to some extent along the temperature scale by changing the proportion of plasticiser; the range can only be increased by the use of expensive plasticisers. Other ingredients of a P.V.C. compound will influence its characteristics, but plasticiser is the most important for the sack user.

P.E. has a much wider effective temperature range in which it can be used satisfactorily and this is probably not influenced significantly by changes in the resin or compound extruded, but may be influenced by the extrusion technique.

In the initial trials, the following 10 thous. inch gauge films were compared:-

(i) low density P.E. of a hard nature in ungussetted open mouth sacks.

(ii) low density P.E. of a soft flexible nature in ungussetted open mouth sacks.

(iii) low density P.E. of a hard nature in sacks with face valves.

(iv) P.V.C. with a low cold flex temperature characteristic ($-18^{\circ}C$ by Clash and Berg test) in both ungussetted open mouth sacks and sacks with corner valves.

(v) P.V.C. with a high cold flex temperature characteristic ($-2^{\circ}C$ by Clash and Berg test) in both ungussetted open mouth sacks and sacks with corner valves.

Filling was carried out in the winter months and the following points were established :-

(a) the output rate from the bagging plant increased with increasing rigidity of the film. Stiffer sacks were easier to present to the filling spout.

(b) discharge of 1 cwt. of fertilizer into a sack freely suspended from a filling spout caused weld failure.

(c) the harder of the two P.E. films was easier to handle but failed more due to snagging.

(d) the P.V.C. with the higher cold flex characteristic was subject to excessive weld failures and bursting during handling and transport.

(e) the P.V.C. with the lower cold flex characteristic stretched under load and the sacks were difficult to handle and stack because of deformation. These problems were found to be increasingly severe under summer conditions, when stretching could proceed to the point of film failure.

(f) at all stages P.V.C. sacks, because of their greater elasticity, were more resistant to failure by snagging.

In subsequent work no major changes were made to the nature of P.E. films tested. However, two further types of P.V.C. were examined. The first of these was a modification of the harder film brought about by an increase in the proportion of plasticiser. The second was the result of a change in formulation including a change of plasticiser. Both these films had a cold flex point of

about $-12^{o}C$.

Test work carried out on these modified P.V.C. films showed marked advantages over those used in the initial tests; sacks retained their shape under both summer and winter conditions, handled easily, stacked well and failed less by snagging than either of the two types previously examined.

The early results obtained on P.E. have been confirmed. Changes in the gauge of any given type of film or formulation have only tended to heighten the main effects.

The inclusion of pigment in P.E. and P.V.C. films was not found to have a significant effect on performance.

4.2 Resistance of films to fertilizers and weather

Plastic films can be expected to suffer degradation on long exposure to sunlight. Large numbers of sacks of different types containing a variety of fertilizers have now been exposed to all weathers and in only one case has deterioration of the film been shown. This occurred with P.V.C. and P.E. sacks containing a high nitrogen fertilizer exposed to sunlight. The "attack" took the form of discoloration of the unpigmented sacks. Measurements made on the films, after six months exposure, showed that a reduction of 50% had occurred in tensile strength of the P.V.C. film and 30% in the case of P.E. Where sunlight was absent from the system, the P.V.C. sacks had retained 90% of their original tensile strength, but the P.E. sacks had still lost approximately 30%. Tear strengths of the P.V.C. sacks had been similarly reduced, but that of the P.E. sacks to a lesser extent. In all cases, however, it is significant to record that flat drop tests still showed all sacks to be satisfactory for normal handling operations.

P.E. and P.V.C. sacks were unaffected by granular fertilizers of high free acidity (about 6% as P_2O_5) and low moisture content (about 2%) in both works tests and

in accelerated tests of elevated temperature on the laboratory scale.

4.3 Strength of film in relation to its performance

Both 10 and 8 thous. P.E. and P.V.C. films have tensile strengths considerably in excess of those of a five or six ply paper sack, and all test work has shown that correctly formulated and manufactured sacks in both materials at both gauges are adequate for 1-cwt unit packages. However, this type of measurement does not give a reliable indication of the commercial performance of a plastic sack. As yet it has not been possible to develop any series of laboratory routines which will allow the establishment of a relationship between film characteristics and operational performance. Tests are available for the measurement of seal strengths and for the peel strengths of seals, but so far no acceptable minimum standards have been established. Results will vary with the flexibility of the film, while the tendency of a film to stretch under load will have a marked, and often adverse, effect on the acceptance of a plastic sack.

For these reasons, assessments have been confined to field performance. In this respect, results confirm that there is little difference between the same film either P.E. or P.V.C. in 10 and 8 thou. gauge, while 6 thous. P.V.C. has an adequate strength form a 1-cwt sack, but is unacceptable in other ways.

4.4 Closure of plastic sacks.

Initial tests covered stitched open mouth sacks and valved sacks in all forms of P.E. and P.V.C. Open mouth sacks were sewn and handled successfully without the material splitting at the stitch holes. Neither form of closure was satisfactory when sacks were stored in the open. Water entered the sewn sacks between the stitches, and, especially with P.E., the flap of material above the stitch line acted as a catchment area. Valves opened slightly under pressure and permitted water to enter.

It was, therefore, necessary to examine forms of heat sealing and, if possible, it was preferred that such methods of closure should also allow continuous operation. This was known to be possible with P.E., but, at the time, no means of sealing P.V.C. other than by high frequency welding was known to us and this implied intermittent operation.

Simultaneously, it was necessary to examine the problem of the removal of air from the sack. Earlier small scale tests had shown that air removal by means of a vacuum pump from sacks filled after being placed in a former was not a practical proposition since:-

(a) the rate was extremely slow

(b) the production method complicated

(c) the film, being drawn tightly round the hard granules, fractured and became pin-holed during handling operations.

The sack manufacturer was not faced with the same problems in applying the bottom seal to the sack, as the process was intermittent, and the film was in the form of lay flat tube and, hence, there was no air to eliminate. Furthermore the film was in its virgin form, not contaminated by dust.

Preliminary works scale tests were carried out using a small band sealer for P.E. sacks and a high frequency welder for P.V.C. sacks. Each sack was provided with 6 x 1/32" drilled microholes in a line below the open mouth.

The sealing techniques were considered successful and the sealed sacks maintained fertilizers in good condition in the open for at least six months provided that no ponding of water occurred in the stacks. The air vents, however, were either insufficient or incorrectly placed to eliminate air sufficiently quickly for normal works operation.

Laboratory work had shown very serious loss of seal strength of heat sealed P.E. sacks when dusts, and especially china clays, (used as a coating agent on fertilizers) were present on the surfaces to be sealed. These strength losses

amounted to 75% of that which could be obtained with clean films under similar conditions.

Investigation of commercial types of sealing equipment available capable of handling at least 600 sacks/hour suggested that a continuous band sealer manufactured by Doughboy Industries Inc. of America was in the best stage of development. A machine of this type was obtained, and was thoroughly tested, in the first instance on P.E. sacks. Capacity was at least 600 sacks/hour and the seals, even in the presence of fertilizer and fertilizer coating dusts, were considered to be of adequate strength for normal handling and storage.

Further work indicated that P.V.C. sacks could also be sealed successfully on this machine; seal strengths were found to be equal to those obtained by high frequency welding and, more significantly, it was found that the presence of dust did not cause the same reduction in seal strengths as occurred with P.E.

4.5 Free Space

It was realised that the ease of elimination of air must be associated with the amount of residual air in the sack. Past experience with paper sacks had always shown that a certain amount of "free space" was necessary if the full mechanical strength of the package was to be obtained. Furthermore, all tests on plastic sacks had shown that the tighter the pack, the better the handling characteristics, since the non-rigid plastic film relies on the contents for part of its shape.

Small scale tests were made to relate the "free space" in a filled sack to its performance as assessed by flat drop test. It was found that there was no loss of performance unless the free space, measured in the conventional way, was less than 2½ inches. This was an important piece of information, since the Doughboy machine is adjustable in height and is fitted with cutter blades to trim the top of the sack. Hence the machine could be adjusted to a height corresponding to the bulk density of the fertilizer. Furthermore, by reducing the free space, the amount of air to be eliminated is reduced to

a minimum, and a well-shaped sack which will stack easily is produced.

4.6 Number of air vents

A number of both P.E. and P.V.C. sacks were obtained containing a varying number of microholes formed either by drilling with a 1/32" drill or merely piercing the material with a needle 1/32" thick. These variations covered :-

(i) 3 holes or 3 punctures each end of the sack
(ii) 2 holes or 2 punctures each end of the sack
(iii) 2 holes or 2 punctures open-mouth end only
(iv) 3 holes or 3 punctures open-mouth end only
(v) 3 holes or 3 punctures in centre of sack face

In addition, a P.V.C. sack incorporating a patented "labyrinth" seal for the elimination of air was included in the tests. Both P.E. and P.V.C. films were obtained in varying gauges.

All sacks were filled, transported and stacked, and while this test is not yet complete, it can be said that, operationally, the minimum number and position of air vents acceptable is 4 punctures, one in each corner of the sack. For storage in the open, punctures are to be preferred to drilled holes. Neither the texture of the film nor its thickness had a significant effect on the speed of air removal. For a satisfactory rate of removal of residual air, the tops of the sacks must be folded down over the fertilizer after filling and before sealing.

In our experience, the "labyrinth" type of vent does not allow sufficiently rapid elimination of air to permit maximum despatch rate. The "vent" acts as a non-return valve and, under pressure, it is possible to expel all air from a sack; the shape of the sack becomes fixed and it is found impossible to change its shape since a small amount of air within the sack is necessary to allow the granules to move freely. This makes handling from stacks or pallets, and stacking after transport difficult.

4.7 Handling Characteristics

This must be a largely subjective assessment. In general, it has been found that P.V.C. films are less slippery than P.E. films, especially when wet and can, therefore, be man-handled more easily and more confidently. This applies particularly to stacking, but the effect can be completely overshadowed by any tendency of the sacks (e.g. certain types of P.V.C.) to stretch and lose their shape.

Problems can occur at the bagging plant if the surfaces, both inner and outer, of printed empty sacks stick together, causing delays in presenting sacks to the filling spout. The technique sometimes adopted by sack manufacturers of cutting the extruded tube into sack lengths by means of a hot wire is not recommended since it gives a partial weld. Use of mechanical knives is preferred.

It has been previously mentioned that the sack must be correctly sized for the fertilizer being packaged. Variations in bulk density of the fertilizer can be as much as $\pm$ 10% of the average. Since most sack manufacturers prefer to use a standard tube width, filled sacks vary in length and this raises problems in palletizing and stacking.

It has been found necessary at all times to handle flat and stack flat all plastic sacks and to secure almost complete elimination of air for safe transport and stacking.

4.8 Failure rates

During the sealing operation, particular attention has to be paid to operating temperatures to avoid seal failures. High temperatures will improve seal strength, particularly in the presence of dust, but excessive temperatures can cause thinning and weakening of the plastic immediately below the seal. P.V.C. is rather more tolerant than P.E. in this respect.

Considerable care is necessary in all handling operations. Plastic sacks require more support than paper sacks

at the filling spouts. Continuous belts, wider than the sacks, are preferred to roller conveyors. Belt fasteners must be sheathed to prevent sacks snagging. Transport vehicles must be inspected for projections which might cause tearing, and should be lined with heavy paper or corrugated board. Operators can easily cause damage as a result of heavy footwear or projections on clothes (buttons, buckles etc.,) Soft heelless shoes are particularly recommended for operators engaged on stacking. P.V.C. is considerably less susceptible to operator damage than P.E. and handles better on conveyors.

It is difficult to give anything other than very approximate failure rates, but it has been found that, if attention is paid to the details mentioned, an overall failure rate (filling/transporting/stacking) of about 2 - 2.5% is achievable with 8 thous. P.E. sacks. This figure can be reduced to around 1 - 1.5% with suitably formulated 8 thous. P.V.C. sacks.

Education of everyone responsible for handling plastic sacks, including merchants and customers, is obviously important, and techniques used for paper sacks are often unsuitable for plastics.

4.9 Disposal of used sacks

The accumulation of used sacks presents a disposal problem. Paper sacks can conveniently be burned. It has been found that a very strong fire and free access of air is necessary to burn both P.E. and P.V.C. Both give, on burning, a heavy black smoke which, in the case of P.V.C. may be slightly toxic due to the presence of hydrochloric acid, volatile plasticisers and stabilizers. If there is insufficient air, P.E. melts and becomes a solid mass on cooling.

With both plastics there is the possibility of sale of used sacks for re-use in low-grade plastic products such as flooring and hoses. The price of scrap P.V.C. is higher than that of P.E.

9. SUMMARY

The use of plastic sacks for the fertilizer trade is still a young art, and is one which, because of its economic value to the producer and user, will continue to receive detailed attention and development.

To date, work has been directed towards the production of a plastic sack at a cost approaching that of the paper sack it will replace, and with an equivalent performance. Neither of these objectives has been fully reached. Works trials undertaken have merely indicated the way in which certain films perform and fail, and hence the difference between such films. The next stage must be the development by the polymer producer of resins which can be fabricated by a sack maker into sacks in such a way that the users' objections may be overcome, and field performance improved. This stage will involve close co-operation and possibly integration between the three bodies concerned. The plastics field is continually changing and developing, as has the paper industry in the past, and it is by no means certain that the ultimate material for a plastic sack will be either P.E. or P.V.C. Fabrication may, in the near future, include gussetting and even the manufacture of single or multiply, block-ended, plastic sacks, provided that the associated sealing problems can be overcome; to obtain such sacks, the film must be creased and folded without loss of strength and this may favour P.V.C. at the expense of P.E.

In Fisons Fertilizers Limited we have reached the stage where we consider that both P.E. and certain forms of P.V.C. sacks are sufficiently developed for their commercial use, and are of adequate quality to permit storage of fertilizer in the open. In the current year, a considerable portion of our production is being marketed in sacks of both types .

DISCUSSION

Mr. E. W. SCHWEHR (United Kingdom) : It has always been our practice in Fisons Fertilizers to thoroughly test, within our own organisation, any modifications, however simple, that we decide to make to a package before we adopt it for commercial use. To us, the arrival of plastic films made up into sacks was just such a modification. It was, however, a modification which, theoretically at least, could result in a great overall potential economy to all sections of the trade, from the manufacturer to the farmer, the ultimate user of our products.

In the paper, I have set down the types of problems which we encountered and had to overcome before using plastic sacks commercially on any large scale. I have intentionally refrained from giving detailed lists of types and causes of failure, since it has been our experience that the overriding cause of failure is loss of package and loss of material, due to the snagging and puncturing of the sacks during handling. This is entirely dependent on the means of filling, handling and transport at the producing works and at subsequent stages. Accordingly, it will vary greatly from one works to another and from one type of user to another. We are confident, however, that by attention to detail and education of the user at all stages, losses due to sack failure can be kept to acceptable levels, and that the plastic sack can be used successfully for outside storage of fertiliser, without a significant deterioration in the condition of the fertiliser at the time of use.

Mr. W. MAK (Netherlands) : Mr. Schwehr's paper deals with the same general subject as that of the paper presented by Mr. A. T. Brook at the I.S.M.A. Technical Conference at Cambridge, in 1953. Mr. Brook related the experience of Fisons, as well as certain experiments undertaken, in the field of fertiliser packaging; and I am sure that all who know of Mr. Brook's paper have read Mr. Schwehr's paper with keen interest. The use of plastic sacks for fertilisers is now in full development and confronts us with many problems. Plastic offers many possibilities, but also many dangers. As

the author says, there are too many variables and, so far, not sufficient laboratory routine to control these variables. It is thus very instructive to study the experience of others, especially the results of such a comprehensive investigation as is indicated in this paper.

My company, Windmill Fertilizers, also has some experience with plastic sacks made of 10 thous. inch gauge P.V.C. which is mostly in accordance with this paper. We have had difficulties with open-mouth sacks which are sewn, because the material tended to split at the stitch holes. We also had trouble with valve sacks, similar to that mentioned by Mr. Schwehr: closure was bad, and the product in the sack became wet around the valve after a few months. We tried to overcome this by closing the valves with glue or tape, but this was very expensive and time-consuming. We also had trouble with dust in our trials with heat-sealing. This could be overcome by a system known as tape-oversealing, but then you are likely to have increased machine trouble.

On page 7 of the paper, Mr. Schwehr states that sealed plastic sacks can maintain fertilisers in good condition for six months in the open; but in a folder dealing with P.V.C. sacks I found that P.V.C. film of 0.3 mm has a water vapour transmission of 3 g. per 24 hours per m^2. In accordance with this, we found that after four months trial in the open during the winter, the fertiliser in contact with the plastic had become wet to a certain degree. In this connection the type of fertiliser is very important, and I suppose this problem would be more serious with more hygroscopic fertilisers.

We had the same experience with micro-holes in the bags. They were useful in the elimination of excess air during filling and closing, but after four months trials in the open during the winter, we found a visible increase in the humidity of the fertiliser around the micro-holes, especially with fertiliser high in nitrate.

On page 5 it is stated that, after six months exposure, there was a reduction of 50% in the tensile strength of the P.V.C. film.

Could Mr. Schwehr say what the tensile strength would be, say, after twelve months ?

On page 11, we find that an overall failure rate of 2% - 2½% was achievable. Does this relate to sacks stored for a short time, or a long time ?

On page 6, it is stated that 6 thous. P.V.C. has adequate strength for a 1 cwt. sack but is unacceptable in other ways. What does Mr. Schwehr mean by "other ways" in this context ?

On page 5, Mr. Schwehr says there was some deterioration in plastic sacks containing a high nitrogen fertiliser exposed to sunlight. I should like to know what is meant by "high nitrogen" here, and what kind of nitrogen is referred to. Are there any theoretical reasons why nitrogen compounds should attack plastics ?

Finally, I should just add that I could not find any mention of the dimensions of the sacks. We have used two different dimensions and have found that narrow sacks - 35 cm x 45 cm - are easier to fill and handle than the broader ones.

Mr. SCHWEHR : The first question related to the experimental finding of a loss of strength in a certain section of sacks. This was an isolated occurrence, in that we have not been able to repeat it, even with the same film. Again, the loss of strength is demonstrated here by the reduction of the tensile strength of the film before and after exposure; but I do not know what this means in terms of sack performance, because although such tests as this reveal an apparent deterioration in the film, these sacks handled perfectly satisfactorily without excessive failure rates. In the early days of our work on these sacks, we had to try to discover methods of a more or less rigorous nature which would tell us what was happening. This particular form of test was made only at that period of time and was subsequently discontinued. Whether this failure continued or not, I do not know.

With regard to the unacceptability of 6 thous. P.V.C. sacks, the reason for this was their tendency to lose shape and their poor stacking characteristics. But, mechanically,

they were quite sufficiently strong.

The nitrogen fertiliser which attacked the P.V.C. bags was, in fact, a 16-9-9 formula, containing totally water soluble P_2O_5 with 9 units of the N from ammonium nitrate. The compound thus contained free ammonium nitrate in its finished form; but, as I mentioned, we have not been able to repeat this. There was no urea in this fertiliser, and, in fact, we do not use urea in any of our fertilisers.

As far as the general handling of plastic sacks is concerned, I think the whole secret of success is to ensure that the sacks are full. The only rigidity in the film is provided by the contents.

Mr. A H. MØLLER (Denmark) : In my company we have also made certain experiments with the external storage of fertilisers in heat-sealed polythene bags. We found, however, that after a sunny day, with a temperature of, say 20°C, followed by a cold night at about 5°C, moisture condensed on the internal surface of the sacks, flowed down and thus spoiled part of the contents. Have you experienced the same problem ? Could you say how low the moisture content of the fertiliser should be in order to avoid this condensation under these conditions ?

Mr. SCHWEHR : Yes, we have seen this phenomenon in our own test work. I think we have possibly always been somewhat afraid of the possibility of entry of moisture into the sack through the micro-holes. Theoretically, one can calculate water vapour permeabilities of films, but these have no significance whatever when micro-holes are made. But I think we have been somewhat unnecessarily afraid: theoretically one can calculate that the fertilisers ought to have set in a solid lump in a very short time, but in practice this does not happen for quite considerable periods of exposure. One must remember that there is considerable protection from neighbouring sacks, thus impeding the entry of moisture when the sacks are in fairly large stacks. We must concede that a proportion of the sacks in a stack will show some setting, but from our experience this proportion is quite small; and the total amount of set material in a heat-sealed bag with micro-holes is itself quite small,

unless there is actual fracture of the film in any position, when, of course, the fertiliser will set solid. However, in this respect one must remember that granules are fairly hard and can, themselves, by sheer attrition cause fracture of the film.

When a plastic sack of fertiliser is left in the open, one finds in the course of time a small lump of material which has built up under the micro-hole. The granules immediately beneath the micro-hole can become completely degranulated, resulting in a small area of powder. These granules will become knitted together, and the size of this lump will increase with time. But in many cases for periods up to nine months the size of the lump is certainly not large enough to give a farmer serious trouble in his equipment.

Reverting to the condensation mentioned by Mr. Møller, I am not sure it originates from the fertiliser. We have put down fertilisers in outside storage tests with moisture contents varying between 0.3% and 4.5% , and I would not say that we have noticed any difference in the amounts of condensation. In fact, I am not sure that it does not stem from the normal breathing of the sack itself with changes of temperature. The air in the sack breathes in and out and takes in moisture.

Mr. MØLLER : But we had no micro-holes in the bags to which I referred, and so breathing was not possible.

Mr. SCHWEHR : I'm sorry - I misunderstood. In that case, I agree : the moisture must have come from the fertiliser. But, as I mentioned, our fertilisers cover a wide range of moisture contents, and we have not noticed any real difference between them in relation to the amount of moisture condensation in the sacks.

Mr. N. D. GOPINATH (India) : Could Mr. Schwehr say something of the relative humidity and the temperature in which the bags were stored ? In our experience of storing fertilisers in polythene bags manufactured by I.C.I., we find that even if we heat-seal the bags, without micro-holes, and keep the fertiliser in a relative humidity of 75% - 80%, it

has absorbed a certain amount of moisture after about three weeks. We carried out a simple experiment in our laboratory which proved this. We took a sealed bag of about 5 cm. in diameter and put it on a beaker containing water. If you take the bag off the beaker after about three days, you find that moisture inside it has increased the weight of the bag considerably. Could Mr. Schwehr explain whether this is due to the relative humidity ?

Mr. SCHWEHR : I have never tried to relate humidity conditions to performance. We have a certain range of weather conditions in the United Kingdom, and we have merely exposed our bags to these conditions in various areas of the country, to cover the existing variations in our climate in regard to humidity and rainfall. All films have a certain water vapour permeability, and thus, in the course of time, presumably in saturated conditions there must be some intake of moisture through the film. But I should not have thought that in a completely hermetically sealed package, this would have been sufficient to have affected the storage quality of the fertiliser within the expected storage period of, say, up to nine months.

Mr. GOPINATH : In India, where the relative humidity is high, as well as the rainfall, our experience, after only three months storage, is that the bags absorbed about 2% of moisture in the case of ammonium sulphate, ammonium nitrate and even urea.

Mr. SCHWEHR : I think this can probably be ascribed to poor sealing, since you have no micro-holes in your bags. There may be minute air passages in your seal, caused possibly by the presence of dust on your sealing surfaces. Alternatively, if you are over-taping, there is always the possibility of moisture entering at the two corners of the bag.

Mr. A.C. VAN ES (Netherlands) : Mr. Schwehr mentions in his paper that polyethylene has a tendency to become slippery. Our experience with handling the bags by manpower is that, with unprotected hands, the fingertips of the workmen become very painful. Then they tend to use their nails, and this results in tears in the bags. Is it customary in Fisons to use

gloves for this operation ? If so, which type of glove is preferred, and do you also advise your client to use these gloves ?

Mr. SCHWEHR : This effect on the workmens' hands is particularly noticeable when the bags are being handled in wet weather in the open. I think men on a normal day's shift can quite happily handle dry polyethylene bags without excessive soreness. They do, indeed, have to learn how to handle them properly. But I agree that, as the bags become wet and slippery, the men do tend to put their fingers in more firmly, and 8 thous. and 10 thous. film in particular are quite easily pierced by mens' fingers - or if not actually pierced, the film becomes stretched and a weakness results. We have not found it necessary to use gloves with dry bags, but with wet bags we found it necessary during some of our early experimental work to issue the men with gloves. These were cloth gloves and appeared to be quite satisfactory, but we did no investigation into the most suitable type of gloves. However, I do not think the gloves should have grips on them, and a plastic glove would be quite useless. I think a cotton material would be best.

Another point to remember when handling wet bags is that one must give the men very considerable weather protection, because in handling a hundred wet bags a man can otherwise be soaked right through to his skin: the amount of water held on the surface of a plastic bag is quite high.

Mr. CARPENTIER (ISMA) : I should like to speak from the point of view of the consumer and ask Mr. Schwehr how the plastic sacks have been received by the farmers. Mr. Van Es has alluded to handling difficulties. I suppose that these difficulties are the same for the farmers. Up to now paper sacks were disposed of by burning. What do the farmers do with the empty plastic sacks ?

Mr. SCHWEHR : Firstly, I think the difficulties of handling are more applicable to the manufacturer and the larger merchant, rather than to the farmer. This

is a question of sheer numbers of bags handled. The problems are, however, naturally quite similar between the farm and the manufacturer.

Secondly, how are plastic bags received by the farmer? I think everybody has their own ideas on this subject, but it is probably too early to say anything definite. Initially - and we are, of course, still in the initial period - there is some novelty in plastic bags, and the disposal problem has not yet been reached. Many farmers complain about the problems associated with burning even paper bags: if they have to try to burn plastic sacks, their problems will be very much greater. There is, at present, a re-sale value in the United Kingdom, but how long this will continue I do not know. If the whole of the fertiliser trade in the United Kingdom became solidly converted to the use of plastic sacks, I am quite sure that the amount of scrap plastic would be far more than could be absorbed by those sections of the plastic industry which can make use of scrap material.

There is also the possibility of opening sacks up and using them in other ways - lining ricks, lining the silo pits, tractor covers, etc., but this all involves work by the farmer in welding used sheets together into a size big enough for the purpose in mind, and I doubt the economics of the time and effort required for this welding, as compared with buying a sheet of the required size.

Mr. CARPENTIER : Do you not think that the application of fertilisers in the autumn and in the spring, which is normal in our countries, and which generally occurs in fairly wet weather, does not lead to the disadvantage to which you have yourself alluded, concerning wet sacks which might give trouble to farm workers when they pour the contents into the distributors ?

Mr. SCHWEHR : This is true, but again it is a question of quantity. In filling his distributor, the farm labourer is using perhaps five sacks every three quarters of an hour, and so he is not really faced with a difficult problem. On the other hand, in the United Kingdom, where farms are tending to

become "big business", there are a number of farms which operate in groups, and the distances between these farms might be quite considerable. In these cases, most have a central collecting point for seed, produce, fertilisers, implements etc., it will enable big economies to be made in farm operating costs by having the fertiliser delivered straight to the farm. The farmer will not need to use his farm buildings for storing fertilisers, and he can also probably buy them earlier when rebates are at their highest, simply because he does not need to provide storage capacity. Thus, I think that the use of plastic sacks for fertilisers could give the farmer greater economies than other sections of the trade will obtain from this practice.

Mr. P. M. R. VERSTEEGH (Netherlands) : On pages 7 and 8 of the paper, you comment on the influence of dust on the strength of the polythene seal. You say that a Doughboy sealer gave a reliable seal, even in the presence of dust. Are we to understand that you do not take any precautions to prevent the adherence of dust on the sealing surface ? If you do, what are these precautions ?

Mr. SCHWEHR : As far as the presence of dust on the sealing surface and the desired strength of the seal are concerned, this is again a question of standards : how is one to measure the problem ? If one carries out the standard plastic tests, with a seal with and without dust, the loss of strength can be quite clearly demonstrated, but this does not mean that the lesser strength is not amply sufficient for the purpose. However, to a large extent the presence of dust can be overcome by increasing the sealing temperature. On the other hand, the greater the rise in temperature in the sealing head, the greater the risk of weld thinning at the lower edge of the weld line and of strain at this line, also. It is therefore preferable to aim to operate at the lowest temperature which will provide a good commercial seal. One should thus take care to see that dust on the sealing surface is reduced to a minimum, and this can be achieved

by ensuring that the surface of the bag filling spout does not become caked with fertiliser. This is the commonest source of contamination. Similarly, at the moment when the sack breaks away from the filling head, there is a little puff of dust which emerges and falls right on to the surfaces which are to be sealed. This can be overcome by introducing a small air-suck into the filling head of the bagging plant, and arranging for this to operate when the bag breaks away.

Mr. H. C. KIDD (United Kingdom) : Could Mr. Schwehr give his opinion of the likelihood of the complete, or at least substantial, displacement of paper sacks by plastic sacks ? In this connection, does he consider there is a case for a water-proof paper sack - for instance, one which incorporates ore or two plys of plastic ?

With regard to the danger of slip between layers in stacks of plastic sacks, could Mr. Schwehr say whether printing has any effect on reducing slip and, if so, whether this is a justification for printing on both sides of the bag ?

Mr. SCHWEHR : The first question relates to the customers' reaction to these plastic sacks and is thus similar to Mr. Carpentier's earlier question. One of the major fertiliser producers in the U.K. is now operating 100% with plastic sacks. The remainder are moving in the same direction, but rather more slowly, and I should certainly not like to say whether plastic will entirely replace paper. One cannot divorce this question from economics, and there is, of course, a price differential between a paper and a plastic sack. There are additional costs in handling plastics, as compared with paper, and these factors must all be taken into account. Similarly, we have to bear in mind the forecast price for plastic as compared with paper.

With regard to the second question, a combination of plastic and paper is, indeed, more than a possibility. We have done some preliminary work on this ourselves, and the results have been quite promising. But again the economic aspect intervenes, and in this case I think that, broadly speaking, there would be very little difference between the price of plastic-paper combinations

and an all-plastic bag, and one might have to show significantly improved handling and storage characteristics in order to justify it, because one would tend to find it fairly difficult to persuade the farmer of the idea that there is now a paper sack which can be stored in the open for nine months or a year.

Concerning the printing on sacks as a method of reducing slip, I do not think this contributes at all to this factor, and two-side printing can be justified only on grounds of eye-appeal.

Mr. A. GEORGIOU (Greece) : In view of the fact that many fertiliser manufacturers are obliged, for a variety of reasons, to bag their ferilisers immediately after granulation, and that these fertilisers are usually warm, I should like to ask Mr. Schwehr whether he has any experience of the effect of the temperature of the bagged material on the mechanical resistance of the sacks.

Secondly, has Mr. Schwehr had any experience of the height to which one can stack the filled sacks without their deteriorating, in view of his suggestion that plastic sacks can be stored in the open air without the use of sheds or covers ?

Mr. SCHWEHR : With regard to bagging temperatures, one must consider the film which is being used. Personally, I have not bagged fertiliser in either P.E. or P.V.C. sacks above a temperature of about 38°C. In the case of P.E., there should be no problem in this respect : one could bag up to quite high temperatures, probably as high as 60-70°C, without serious trouble. In the case of P.V.C., serious trouble would occur above 40°C, because there is a rather limited temperature range within which a P.V.C. film has an effective shape without stretching too much, and if one has made allowance in the formulation for good performance at low temperatures, one cannot have good performance at high temperature as well. However, I should imagine there is no real difficulty in bagging with either material ex-plant,

provided the plant is equipped with a cooler.

The second question related to the height of the stacks. We have quite successfully stacked P.E. and P.V.C. sacks up to 30 - 35 sacks high, taking due care to see that each layer is reasonably held by the layers above and below, and that stacks are constructed with a slight taper on them in all directions. All types of plastic sack appear to move out slightly in the stack, and although one may build a stack initially with what appears to be quite a heavy taper, one has a fairly vertical face within 24 hours.

Mr. ORDONNEAU (France) : I understand from Mr. Schwehr's paper that he has been led, in practice, to prefer open-mouthed, welded sacks, and has abandoned the idea of using valve sacks in plastic. Is this correct ?

Secondly, with regard to the welded sacks, Mr. Schwehr speaks of a machine capable of sealing 600 sacks per hour. Does the limitation on capacity stem from the welding machine or from the dimensions of the remainder of the bagging chain ?

Still on the problem of welding, have you tried sealing sacks containing only powdered fertilisers ?

What is the effect on the seal of irregularities in the thickness of the film originating from a defective extrusion ?

With regard to polyethylene sacks, have you carried out any practical trials to study the variation in the mechanical resistance of these sacks and their resistance to atmospheric factors as a function of the grade of polyethylene used, given identical extrusion conditions (because these are also important).

Mr. SCHWEHR : The first question relates to the use of valve sacks. We have tried using face-valve and corner-valve sacks, the former in P.E., and the latter in P.V.C. Despite taking considerable care with regard to the way in which these sacks are stacked, we do not feel that either of these valves are sufficiently fool-proof to guarantee the condition of the fertiliser in outside storage. Therefore, we would not recommend them. We have used valve sacks with thermoplastic tape to seal the valves,

but the operation is extremely slow and expensive and again does not provide an adequate solution : it merely reduces the number of failures. It seems a little absurd to me that, when one has a means of producing a sack which, apart from the micro-holes, is almost perfectly hermetically sealed, one should revert to the use of valve sacks. The valve sack itself, apart from these other considerations, will cost considerably more than an open-mouthed sack.

Our figure of 600 sacks/hour was limited entirely by the general operating level of the pre-weighers on our bagging units. The Doughboy sealers can work up to rates of 1200 sacks/hour, and, depending on plant layout, it is obviously possible to streamline bags from several filling plants into one single Doughboy unit.

We have never heat-sealed powdered fertilisers in plastic bags.

In purchasing our plastic bags we have specified to our suppliers a maximum spot variation in extrusion thickness of 1 thous. We are working with sacks with a thickness of 8 thous. of an inch, and we thus allow a spot tolerance of $\pm$ 1 thous. or 12½%. Under these conditions we find no difficulties in sealing caused by gauge variation. More often than not, this variation is localised and does not extend right round the bag.

With regard to the final question, as to whether we found performance variations between the different grades of polyethylene film, we did indeed, but I do not think I can fairly illustrate this in discussion, because obviously it is quite detailed. One has to make a compromise, because if, for example, we compare a soft and a hard film, one may give a lower failure rate at certain stages of the operation, whilst the other may handle much better at another stage, thus perhaps giving it an overall lower failure rate. One must always consider the <u>overall</u> failure rates and examine where one can adjust equipment to take advantage of a lower failure rate at a particular stage in respect of a

particular film.

Mr. W. WEBER (United States) : My company has been approached by experts in the field of plastic bag manufacture with a view to promoting the idea of manufacturing the bag at the fertiliser works. We are told that in a highly developed country such as the U.S.A. this would be an economic proposition above a production of about 250,000 tons per year. We are rather sceptical of this possibility in countries where bag manufacturing facilities are plentiful, but it may be an interesting possibility for the under-developed countries, where plastic bag manufacturing facilities may not be available otherwise. Such a facility could perhaps be included in the design of a complex. I wonder if Mr. Schwehr has any views on this.

Mr. SCHWEHR : I have not examined this so closely as to be able to say where the economic level would be. It would quite obviously be a convenient thing to do, in so far as the output of extruders, which comprise the basic unit, are relatively low, compared with paper sack manufacturing equipment. But if any works were to consider this possibility, they would have to acquire a completely different technology, and I believe the plastic industry is extremely technological.

There would thus be this objection to it, and, in addition there would be virtually no saving in transport costs, because the weight of the bags themselves is not a significant factor. One would also have to acquire some printing technology, and printing on paper is much easier than on plastic films.

Thus, whilst it is quite obviously a possibility, I think it requires a great deal of investigation before the step is taken.

Mr. J. FROCHEN (France) : Can Mr. Schwehr give us some details concerning the handling and storage of plastic sacks on pallets ?

Mr. SCHWEHR : We are using pallets ourselves, with both wooden pallets and skid pallets. We have found it necessary to put a sheet of cardboard on to all wooden pallets, and it

appears to be preferable that this cardboard is loose rather than fixed, in order to prevent nails and screw-threads working their way through it. We normally stack on each pallet six sacks high in layers of five, giving us thirty sacks to each pallet, and we then usually cover the top of the stack with a sheet of plastic, or hardboard, or perhaps an old skid pallet, before the next pallet load is placed on top of it. We are finding no difficulty with the use of fork-lifts, in connection with plastics, and we are stacking three or four pallets high, depending on whether the pallet groups are free standing or whether we can take advantage of a wall as a backstop. There is, however, a slight loss of warehouse capacity at present in the palletisation of plastic sacks, as compared with paper sacks.

Mr. F. NOUYRIGAT (France) : I should like to ask Mr. Schwehr whether I have correctly understood his position concerning the factors involved in choosing between P.V.C. and polyethylene and whether he is still of the same opinion on this matter since preparing his paper, namely that neither of these two materials has any overriding advantage. Also, with regard to the certain forms of sacks in P.V.C. which he mentions, can he tell us more exactly what are these "certain forms" which he considers to be sufficiently developed to be put into current use?

In addition, I should like him to confirm that the relative welding difficulties observed with polyethylene do not offset the advantages of this material from certain points of view.

Mr. SCHWEHR : I do not think the choice of P.V.C., as opposed to P.E., is really a problem. We should like to know much more than the mere testing of 50,000 bags has told us, and I think we shall, in due course, know much more on this subject; so that at this stage I should certainly not be prepared to express a preference. Each material has various advantages and disadvantages relative to the other, and one must on this basis assess which suits one's particular market and procedure

better.

The second question is also difficult, because the modifications we have made in P.V.C. formulations have really been designed to suit our own particular market in the U.K. You may have quite different weather conditions, so that a general specification of the P.V.C. formulations we have used might not be of very much use to you.
