Development of “Integrity Seal” Back Sealing Technology

Development of “Integrity Seal” hermetic sealing technology for the back seals of flexible packaging, and application in the food industry.

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Front cover photography: A Florette Mixed Salad pack produced at the Soleco UK Ltd factory in Lichfield showing the new style back seal developed for continuous motion sealing machines. A similar system has also been developed for intermittent motion machines.

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Executive summary

Many food products have a limited shelf life because the seals, which form flexible bag packaging, are not hermetic, allowing unwanted changes of headspace gases, moisture loss or uptake. When seals leak, it makes it impossible for the packaging material to control the level of barrier or permeability required for the product. This means that the product may well not achieve its desired shelf life and either has to be disposed of in-store or more likely thrown away by the consumer.

In 2005, WRAP awarded funding to International Food Partners (IFP) Ltd to develop a commercial technology for reducing the amount of packaging material used to make the top and bottom seals (cross seals) on flexible bags. By replacing the conventional crimp seal by a cut and weld impulse bead seal technology (Integrity Seal), the amount of film used to make the seal could be reduced from 15 mm to 1 mm, a saving of around 10% in the length of the bag.

It was recognised, however, that although the new cross seal technology was successful in reducing the film usage and also making the seals hermetic, this would be of little benefit if the bags were still leaking via the back seal. Therefore, IFP were awarded funding from WRAP’s Innovation Fund in November 2006 to develop a superior sealing technology for making the back seal on flexible packaging, which would both reduce the amount of packaging material required to form the seal and ensure that the seals were hermetic.

The width of the back seal bars are generally 8 - 10 mm so a significant amount of film is used in an attempt to make the seal hermetic. In reality, the width does not contribute to making an hermetic seal so is an unnecessary use of film. The Integrity Seal systems use only a 4 – 6 mm wide seal so a 50% reduction in the seal width is possible. It is not possible to reduce the width any further because of the film tracking which is always present on vertical form-fill seal machines.

The Integrity Seal technology works by rapidly heating the low mass impulse element to beyond the polymer melt temperature. The impulse bar presses against a rubber pad mounted in the product tube. The pad comprises an embossed surface which transfers points of high pressure to the seal thereby making an hermetic seal. Before the seal bar retracts, it is cooled by the chilled water circulating behind the element. This rapidly removes the heat and sets the polymer. The seal created is hermetic and does not have the common crease line which is present with the conventional hot bar systems.

The objective of this project was to make an hermetic seal using a rotary heated wheel system for continuous motion machines and an impulse or constant heating system for the intermittent motion machines. A main characteristic of all the systems was the development of an embossed feature to deliver more pressure and thereby produce hermetic seals.

Prototype designs were built and evaluated by Ceetak at their Bedford facility, and products were tested for seal strength and seal integrity. Trials and production runs took place on fresh produce at Tilmanstone Salads (Sandiacre intermittent machine) and Soleco (Ilapak continuous motion machine). The trials were successful and demonstrated that hermetic seals were produced by both systems under production conditions. The benefits of these new technologies can be summarised as follows:

- hermetic seal;
- narrow seal profile;
- seal area reduced by 50%;
- film width reduced by 1%;
- potential film saving from using thinner gauge film of 10 - 15%;
- improved pack appearance;
- better temperature control; and
- potential improvement in product quality and shelf life.
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1.0 Project scope

Many food products have a limited shelf life because the seals, which form flexible bag packaging, are not hermetic, allowing unwanted changes of headspace gases, moisture loss or uptake. When seals leak, it makes it impossible for the packaging material to control the level of barrier or permeability required for the product. This means that the product may well not achieve its desired shelf life and either has to be disposed of in-store or more likely thrown away by the consumer.

1.1 Background

In 2005, WRAP awarded funding to International Food Partners (IFP) Ltd to develop a commercial technology for reducing the amount of packaging material used to make the top and bottom seals (cross seals) on flexible bags. By replacing the conventional crimp seal by a cut and weld impulse bead seal technology (Integrity Seal), the amount of film used to make the seal could be reduced from 15 mm to 1 mm, a saving of around 10% in the length of the bag. In addition, the potential to improve product quality by eliminating seal leaks could have a significant impact on reducing food disposed of due to premature spoilage and loss of shelf life. This project was successful and Marks & Spencer decided to implement the system for bagged salads at one of their key suppliers. IFP are now supplying systems across a number of food sectors, such as frozen chips, whole potatoes and other fresh salad companies (see [http://www.wrap.org.uk/retail/case_studies_re...](http://www.wrap.org.uk/retail/case_studies_re...)) for further details and reports).

It was recognised, however, that although the new cross seal technology was successful in reducing the film usage and also making the seals hermetic, this would be of little benefit if the bags were still leaking via the back seal. All companies that IFP approached stated that they still have a major problem with packs leaking through poor back seals. They indicated that they would like to see the same improvements on a back seal system as those achieved for cross seals.

IFP were awarded funding from WRAP’s Innovation Fund in November 2006 to develop a superior sealing technology for making the back seal on flexible packaging, which would both reduce the amount of packaging material required to form the seal and ensure that the seals were hermetic.

Traditionally, the method of closing the bag’s back seal is by flat sealing bars or constantly moving heated bands. These techniques have been used for many years and rely on the width of the seal to produce a degree of air tightness. Flat bar or band sealing cannot produce hermetic sealing with thin gauge monolayer polymers such as Oriented Polypropylene (OPP). Flat profile sealing relies on the thin layer of sealant on the face of the film, usually just a few microns thick, to make the heat seal. Such a thin layer is insufficient to melt, flow and make the seal hermetic. Rigid flat bars and bands are incapable of applying optimum pressure across the full width of the seal. In the case of the intermittent system the bar has to touch the film twice to ensure an overlapped seal is made. This means that when the film is touched the first time, the area under the seal bar is heated and clamped but the film adjacent to the end of the bar is not clamped and is therefore free to move. Consequently when the tube moves down to the next position and is heated again, the bar compresses some of the film which has been heated once already and some which has not, hence a horizontal crease is produced and the flat seal bar cannot iron out that crease. This leads to the production of a leaking seal. It is also common to find additional random creases present where the film tension has been lost and extra folds develop. A prime objective of this project was to eliminate this crease.

Laminated films are sometimes used in an attempt to produce hermetic seals and they can be successful but cost more to manufacture and use more polymer. Typically the sealant layer on a laminate is 12 – 20 micron with a substrate layer of 15 – 20 micron, so a total thickness of 35 – 40 micron. The width of the back seal bars are generally 8 - 10 mm so a significant amount of film is used in an attempt to make the seal hermetic. In reality, the width does not contribute to making an hermetic seal so is an unnecessary use of film. The Integrity Seal systems use only a 4 – 6 mm wide seal so a 50% reduction in the seal width is possible. It is not possible to reduce the width any further because of the film tracking which is always present on vertical form-fill seal machines.

Machine operators can also be inclined to increase sealing temperature in a belief that more heat makes better seals, when in reality this can lead to poorer sealing. The polymer will try and run from the heat source and with uneven bar pressure the polymer will thin down in the areas of higher pressure.
Traditional impulse sealing technology has been in existence for many years but has not been used widely because of its limited speeds and poor reliability. The Integrity Seal technology, however, is a new generation of impulse technology combined with innovative seal jaw design and water cooling.

The Integrity Seal technology works by rapidly heating the low mass impulse element to beyond the polymer melt temperature. The impulse bar presses against a rubber pad mounted in the product tube. The pad comprises an embossed surface which transfers points of high pressure to the seal thereby making an hermetic seal. Before the seal bar retracts it is cooled by the chilled water circulating behind the element. This rapidly removes the heat and sets the polymer. The seal created is hermetic and does not have the common crease line which is present with the conventional hot bar systems.

Whilst a single technological solution was possible in delivering the Integrity Seal for cross sealing, this was not possible for the back seal. Differences in existing machine platforms meant that two systems had to be developed and proved; one for continuous motion machines and one for intermittent motion machines.

The objective of this project was to make an hermetic seal using a rotary heated wheel system for continuous motion machines and an impulse or constant heating system for the intermittent motion machines.

**1.2 Aim of the project**

The project sought to find a way of sealing films under better temperature and pressure control in a way which reduced film usage and delivered hermetic seals. IFP approached Ceetak Ltd, a UK company specialising in sealing systems and rubber products, and asked them to develop a sealing technology which would guarantee hermetic seals.

Key factors in the design brief were reliability, low cost, ease of operation, operator safety and maintenance.

The designs should also be easily retro fitted to the wide range of existing machine types used in the industry, for example, Ilapak, Sandiacre, Bosch, Rovema, CFS, GIC etc.

The designs must also be capable of coping with film tracking which is an inherent feature of all bagging machines. As the film is pulled from the reel through the tensioning rollers and across to the product tube the lateral position will wander from time to time and change the amount of overlap in the back seal. Although the objective was to reduce film usage and make a narrow seal the limit was governed by the variability of this overlap.

Another objective was to improve the appearance of the seal. Flat bar and band seals do not look very attractive when set incorrectly because the flat surface is not very tolerant of excessive temperature. It was therefore proposed to use embossing as a means of improving both the seal appearance and performance.

**1.3 Timescales**

The project began in November 2006 and was completed at the end of May 2008.

**1.4 Project partners**

The project was initiated by International Food Partners Ltd and included the following partners:

- Ceetak Ltd (system manufacturer);
- Tilmanstone Salads (leafy salad producer); and
- Soleco UK Ltd (leafy salad producer).
2.0 Project methodology

2.1 Stage one
The first stage of the project involved setting up laboratory trials at Ceetak Ltd. using a vertical form-fill seal bagging machine to test the prototype designs and establish their operating parameters. Film samples were obtained from all the manufacturing partners for the trials and retail packs were purchased so that the seal integrity of current bags could be tested. The seal quality was measured by a combination of vacuum immersion tank tests and penetrative dye tests. Optimum settings were found for each material type which produced hermetic seals. Designs were then finalised for commercial scale trials and rigs constructed.

Figure 1 Test rig at Ceetak.  Figure 2 The prototype intermittent design.

Figure 3 The prototype continuous design.  Figure 4 The prototype continuous motion design – parts ready for assembly on the Ceetak bagging machine.

2.2 Stage two
The second stage of the project involved setting up the new rigs on production machines at each of the partner companies to run trials under commercial conditions. Fresh leaf salad was run at Tilmanstone Salads and Soleco UK Ltd. on Sandiacre and Ilapak machines respectively. Modifications to the design were made where necessary and repeat trials undertaken.

During the trial the following data were collected:

- machine speed;
- strength of the seal - vacuum immersion tank test;
- micro leak level – penetrative dye test;
Limited shelf life trials were undertaken during this project, but unfortunately it was not possible to run the back sealing trials on a machine having the Integrity Seal cross sealing jaws. This meant that although successful hermetic back seals were formed, these were on packs having standard crimp-cross seals. As a result no differences were seen between packs having the standard or new back seals.

2.3 Project success criteria
Project success criteria were agreed with WRAP and the project partners. They included the following:

2.3.1 Sealing jaw performance
- the systems can be easily fitted to existing machines;
- the system can work on servo and pneumatic machine types;
- the life of the system is comparable to existing technology;
- the jaws are designed for IP 65 rating;
- the jaws can be easily cleaned;
- any components subject to wear are easily replaced;
- all parts are corrosion resistant;
- the control system easily works with other machine functions;
- the system is easy to operate;
- systems are available for both intermittent and continuous motion machines; and
- better temperature control is possible for heat sensitive films.

2.3.2 Pack performance
- uses less material than conventional back seals;
- hermetic seals;
- good pack appearance – no heat distortion;
- high strength seals are stronger than current seals;
- better product quality potential; and
- potential for longer shelf life – sensory and microbiological.

Figure 5 The continuous motion system.  Figure 6 Florette Mixed Salad pack with new back seal.
3.0 Limitations with current technology

Flat profile sealing has been used for sealing the back of the bags on vertical-form-fill seal machines since they were first invented. See Appendix 1 for a summary of current sealing technology. There are some limitations with current sealing technology, which are summarised below.

3.1 Intermittent motion machines

The principle of this type of machine involves using a wide, flat sealing bar, typically 8 – 10 mm wide, to apply heat and pressure for a controlled dwell time to activate the surface layer of the packaging material. The metal bar is rigid, although usually pivoted to allow alignment with the product tube, but it does not apply very high pressure.

Traditionally, a wide seal bar is used in an attempt to make the seal hermetic over at least part of the seal area. This approach however does not solve the common problem of the horizontal creases which occur when the film is heated twice as it moves down the product tube. This is particularly true when there are random, unwanted creases present in the seal area. All the pressure is taken at the thickest points i.e. where there are four layers at the crease point.

The rest of the seal area (with only two layers) receives very little pressure allowing the polymer to flow away from the heat source. Because the film is not held under pressure at these points the film suffers thermal distortion and causes pinhole leaks. Dye tests show that virtually all back seals have pinhole leaks at the overlap edges. Monolayer packaging films commonly used for fresh produce are particularly prone to seal leaks because the active surface layer, which makes the seal, is only 2 – 3 microns thick. Hence there is little polymer present to make the seal hermetic. In an overlap seal, or A to B seal, only the inner sealant layer contributes to the seal.

When hermetic sealing is paramount, it is common to use laminated films with a thicker sealant layer of 15 - 20 microns. Such films are more expensive and use more polymers simply to make a seal.

3.2 Continuous motion machines

The principle of this type of machine involves using a constantly moving steel band which transmits the heat from the block heater to the constantly moving film. Once again a sealing width of 8 – 10 mm is used to produce a wide seal. Flat steel bands are used so the resulting seal is a flat profile. As above, this limits the pressure which can be applied. As the heat source, a cartridge element, is mounted behind the steel band it relies on conductivity to transfer the heat through the steel band to the film. Hence the degree of temperature control and tolerance is limited because the heater is remote.

As the machine stops and starts the steel band and its drive assembly move in and out which means there is a tendency for the first few bags to be overheated because of the stored energy in the assembly. As heat is then taken away by each sealed bag there is a lag before the thermocouple senses that loss and pumps more current to the element. It is therefore very common to see either overheated bags at the start of a run or unsealed bags a little way into a run because the heater has taken too long to pump more heat to the steel band; hence a more responsive temperature would be beneficial.

3.3 Limitations with both machines

On all bagging machines there is a degree of film wander, or tracking, which affects the actual width of the overlapped area. It is impossible to eliminate this random movement of the film and this limits the reduction in the film saving. Nevertheless, if it is possible to produce guaranteed hermetic seals then the actual width of the sealed area can be reduced. The designs therefore proposed for both the intermittent and continuous motion machines from this research provide seals which are 50% narrower than the traditional back seal, which delivers a 1% area saving in film usage per bag.
4.0 The new Integrity Seal solutions

4.1 Solutions for intermittent motion machines

4.1.1 Constantly heated bar

This design features an embossed, coarse profile, constantly heated bar pressing against a flat rubber, heated anvil, mounted in the product tube. It was designed to heat the film from both sides and therefore give better heat transfer through the film to make the seal. In order to mount the heater in the product tube the shape of the tube was modified to a "D" profile. See figures in Appendix 2 (Design 1).

The prime benefit of this design was that the low mass construction of the heater bar giving excellent temperature control. The bar was made from brass and was machine cut with a large coarse profile to emboss the sealed area. Various embossing profiles were used and tested on the machine at Ceetak until an optimum profile was found. A 3 mm wide coarse pattern was found to give the best results, and this was used during trials at Tilmanstone Salads.

During the factory trials it was found that the coarse pattern on the brass seal bar was very rapidly producing a wear pattern on the tube mounted rubber anvil due to the high pressure. When the pressure was removed the seal was no longer hermetic. Although finer embossing would have reduced the wear, it was decided to move to an alternative design; an intermittently heated bar. This move also eliminated the need for a heater inside the product tube. The impulse heating, because of its better temperature control, would obviate the need for additional heating. There was some reluctance with the partners to have heated tubes because of the extra cost and difficulty when changing tubes.

4.1.2 Intermittently heated bar

The concept of this system, which Ceetak developed, was an adaption of the cross seal system but without the cutting action. The Integrity Seal intermittently heated bar is a new generation impulse heating technology which uses a novel means of applying heat to the film. A 6 mm wide bar was used for the trials to ensure the overlap wander, prevalent on intermittent machines, was still sealed.

Conventional seal bars use a resistance heated cartridge element which have a much wider range of temperature and can therefore very often overheat the seal. In this design a very thin, narrow, laminated impulse element heats when triggered by the arm closing signal. The low mass design allows the element to heat very rapidly to the heat seal temperature, typically 180 °C. Because the element is also very narrow, only a small area of film is heated. The seal bar also has a chamber behind the element, which is filled with chilled water. The function of the chilled water is to remove the heat from the element on each cycle thereby cooling the polymer. The seal is cooled in order to harden the polymer so that it has sufficient strength.

The impulse bar presses the overlapped film against an anvil located in the product tube. This anvil provides the embossing feature, which both increases the chances of an hermetic seal being made and improves the seal appearance. The degree of embossing can be altered to suit the polymer type and its thickness. The degree of coarseness of the pattern controls the pressure application to the film and hence the quality of the seal. The embossing eliminates the horizontal crease common with traditional sealing technology. See figures in Appendix 2 (Design 2).

4.2 Solutions for continuous motion machines

The concept of the system which Ceetak developed for the continuous motion machines uses a pair of low mass, heated wheels with a profiled front face. The heated rollers are servo driven from the motion of the side transport belts. To support the pressure of the heated wheels, a pair of jockey rollers are mounted inside the product tube. They are pivoted to self align when the heated rollers move in to compress the film. This design produces a neat 3 mm wide embossed seal of high integrity. The rolling action of the heated rollers prevents creases from being generated. See figures in Appendix 3.
5.0 Factory trials
The fresh produce market was chosen for the initial commercialisation of the Integrity Seal system, and trials of the new back sealing technology, due to the sensitivity of the products and benefits of achieving hermetic seals. In the absence of hermetic seals, shelf life can be compromised. Fresh produce respires from the moment it is harvested to the end of its shelf life. There are different levels of respiration rate sensitivity, some leaf varieties such as Iceberg and Cos lettuce are highly sensitive to oxygen whereas many baby leaf varieties such as Young Spinach, Rocket and Lambs Lettuce are not. It is therefore necessary to use breathable films to control the respiration for each leaf type, by controlling the ingress of oxygen and egress of carbon dioxide from the headspace.

When crimp seals leak this control of gas permeability is lost or severely changed. Leaking seals allow continuous replenishment of the oxygen from the atmosphere which promotes further respiration, producing more carbon dioxide and shortening the life of the product. Hermetic seals control the oxygen ingress by ensuring the oxygen molecules permeate through the packaging material. The objective is to reduce the oxygen in the headspace to near zero and maintain a carbon dioxide level of between 5 and 10%. Less sensitive varieties are more tolerant to oxygen but still benefit from controlled permeability.

5.1 Ceetak trials
Ceetak spent three months working on the design for each system, intermittent motion and continuous motion, before testing the designs on a Line Equipment bagging machine at their plant in Bedford. Details of the products run during the trials are given in Appendix 4. Test data, gathered to verify seal integrity and seal strength is presented in Appendices 5 and 6.

5.2 Manufacturing trials
Two manufacturers were used for the project, to allow the packing of different produce on the two main machine platforms; Sandiacre intermittent motion and Ilapak continuous motion bagging machines.

5.2.1 Tilmanstone Salads: Sandiacre intermittent motion machine
Tilmanstone Salads, as a main supplier to Marks & Spencer, were an obvious partner having been part of the original cross seal project. However, as their factory only uses intermittent motion bagging machines only part of the development programme could be carried out there.

Initial trials on their Sandiacre production machine were conducted in November 2007 using the constantly heated bar design. These were only partially successful and revealed some weaknesses in the design. In particular, it was found that the hot embossed bar was too coarse and not producing sufficient pressure to make hermetic seals. This had not been a problem on the Line Equipment machine. In addition the coarse profile was impacting too much on the rubber anvil mounted in the product tube. The problem of the excessive wear of the rubber only came to light following the extended running under production conditions.

It was decided to rework the design and produce an Impulse bar system using the same technology as the cross seal system. The redesign took three months and a return to Tilmanstone Salads took place in March 2008. During March, successful trials and full scale production verified that the new impulse system gave much better results in terms of integrity and component life. There was no premature failure of the rubber anvil although it was found that a finer embossed pattern gave better results than the coarse pattern.

Production runs:

<table>
<thead>
<tr>
<th>Product:</th>
<th>Marks &amp; Spencer Iceberg Lettuce (250g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging material:</td>
<td>35 micron OPP (30 micron also run in a short trial)</td>
</tr>
<tr>
<td>Gas flushed:</td>
<td>5% O₂ 5% CO₂</td>
</tr>
<tr>
<td>Pack style:</td>
<td>Pillow Pack</td>
</tr>
<tr>
<td>Machine type:</td>
<td>Sandiacre</td>
</tr>
<tr>
<td>Machine speeds achieved:</td>
<td>55 bags per min</td>
</tr>
<tr>
<td>Duration of trials:</td>
<td>March 2008</td>
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</tbody>
</table>

During the factory trials, iceberg lettuce was used as a test product because of its sensitivity to oxygen. Any leaking packs would be easily identified by the oxidative browning.

The impulse system was run in production for two days to verify its consistency and not one leaking bag was found during that time. Tilmanstone Salads was very impressed with the quality of the seals and is therefore considering the commercialisation of the system.
5.2.2 Soleco UK Ltd. Ilapak continuous motion machine

Soleco UK were approached to test the continuous motion machine system. Their Florette brand of bagged salads is the leading brand in the UK market.

Production runs:

<table>
<thead>
<tr>
<th>Product:</th>
<th>Florette Mixed Lettuce (Escarole, Frisee, and Radicchio, 200g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging material:</td>
<td>35 and 30 micron OPP</td>
</tr>
<tr>
<td>No gas flush:</td>
<td>NA</td>
</tr>
<tr>
<td>Pack style:</td>
<td>Pillow Pack</td>
</tr>
<tr>
<td>Machine type:</td>
<td>Ilapak Vegatronic</td>
</tr>
<tr>
<td>Machine speeds achieved:</td>
<td>45 bags per min</td>
</tr>
<tr>
<td>Duration of trials:</td>
<td>March 2008</td>
</tr>
</tbody>
</table>

During the factory trials the Mixed Lettuce was used as a test product as this is the highest volume line for Soleco.

The hot wheel system was run in production for two days, producing over 15,000 bags to verify its consistency and, again, not one leaking bag was found during that time. Soleco were very impressed with the quality of the seals and have expressed interest in combining the benefits with the cross seal technology.

5.3 Results relating to both machines

Both the intermittent motion and continuous motion systems performed to the required standard in terms of machine speed with the potential to run faster. Up to 55 bags per minute were run at Tilmanstone Salads and 45 bags per minute at Soleco. The only reason higher speed trials were not run was due to limited product filling speeds.

The low mass components with both systems produced very quick heating, with start up times reduced by approximately 10 minutes. The improved temperature control with both systems reduced the risk of over heating the film.

All the design criteria were met with both systems so it is now proposed to offer the systems commercially for bagged salad products. The designs are also suitable, however, for all types of bagging machines so will be promoted for all food and non foods packed on vertical form-fill seal machines.
6.0 Film trials
The objective of these trials was to test Integrity Seal technology running two different standard gauge films. The sealing properties were assessed, together with the general machinability of the films, using:

- 35 micron OPP (Run in production); and
- 30 micron OPP (Run under trial conditions).

Both gauges of film were run successfully at both locations. The films were sealed without any issues such as overheating. Thinner films are generally more heat sensitive and prone to thermal distortion when sealed with conventional systems, but the improved temperature control with all the Integrity Seal systems eliminated this problem.

Seal performance data (given in Appendix 7) was obtained from the trials on the Line Equipment bagging machine at Ceetak using various seal profiles on both the intermittent motion and continuous motion designs. Only the designs giving the best performance were taken to Tilmanstone Salads and Soleco for factory trials.

There was no difference in performance on the Sandiacre machine at Tilmanstone Salads or the Ilapak machine at Soleco.
7.0 Benefits analysis

7.1 Packaging material weight saving
The addition of Integrity Seal back sealing will deliver a further 1% film saving in addition to the average 10 – 15% saving from the cross seal technology. Data illustrating the packaging savings from using Integrity Seal technology is given in Appendix 8. This 1% film area reduction will save an additional ca. £1,500 per year, per bagging machine, based on a two shift, six day week operation using a 35 micron OPP type film. If implemented across the UK fresh produce industry, this could save approx 55 tonnes of packaging film per year, or almost 700 tonnes per year if combined with the cross sealing technology.

A gauge reduction from 35 micron to 30 micron would save a further 14% in terms of film weight (whether this gives a 14% price reduction will depend on the policy of the film manufacturers, but certainly offers a further substantial saving). In weight terms this could save over 750 tonnes of film if implemented across the UK fresh produce sector, and almost 1,500 tonnes if both technologies are adopted.

7.2 Product shelf life benefits and reduced wastage
By improving the product quality and extending the shelf life several benefits can be delivered. Firstly, with product lasting longer in the pack, there is a greater likelihood that the consumer will not throw as much away through premature decay. Currently, fresh salads are often dated with matching display and use-by dates. In many cases the average consumer will use their senses (i.e. if the leaf looks and smells good) to decide on whether to use the product, however, rather than rely on the use-by date.

With leaking packs, the leaf very often struggles to maintain quality but with Integrity Seal the leaf will last longer and be more likely to pass the consumer “sensory test”. It may also lead to a longer shelf life for the product making it possible to extend the use-by date helping the consumer plan ahead for meals. The main financial benefit of extended shelf life is the opportunity to optimise production scheduling and distribution. Although stores now primarily use daily deliveries, any potential to reduce delivery costs and impact on the environment should be seriously looked at. The extra shelf life of 2 -3 days, with no resulting loss of quality, could allow for less frequent deliveries to store. Reducing the frequency of store deliveries will reduce fuel costs and help reduce the impact on the environment.

The improvement in the shelf life of fresh salad and a reduction of in-store waste will also reduce costs. Retailers have stated that in-store wastage can be as high as 8% at those times of year when the leaf is delicate. High wastage gets charged back to the supplier so preventing wastage is financially beneficial.

7.3 Other productivity and financial benefits
The better temperature management with all three systems (the impulse and low mass heated wheels and bars) reduces the heat distortion common with back sealing of the overlapped area and helps eliminate the pinhole leaks at the edge of the sealed area.

In the case of the impulse system, the heat is only applied when the seal is being made so that energy is not wasted. It is also not necessary to keep the heat on 24 hours a day, as is common with traditional cartridge heaters. Cartridge heaters frequently fail if they are switched off over night because the moisture, present following the hygiene clean-down, short-circuits the electrics. The Integrity Seal bars are fully protected to IP 65 rating and the element itself is moisture resistant.

The impulse bar cools after every cycle so it is safe to touch when operators are working in the vicinity of the product tube.

The impulse bars are easily cleaned with a fibre glass pencil. The bar also has an easy clean function. This is used when polymer build up becomes excessive. A five second pulse is given to the bar when it is open and away from the film and product tube, resulting in polymer simply falling away from the bar and any film which was stuck to the bar is instantly cleaned.

Integrity Seal is being offered to the market on a range of terms, leased or purchased, and is sold as a profitable system.
7.4 Summary of benefits
Integrity Seal provides the user with many advantages over the current technology and should be considered as a combined solution for bag sealing; both cross and back sealing. If only one of the bag seals is improved i.e. the cross or back seal, the weakness in the remaining seal will reduce or negate the potential benefits.

7.4.1 Commercial benefits
- The 8 – 20% film saving from using a shorter bag and the potential to use thinner gauge film without loss of integrity, delivers a substantial environmental benefit. For every five micron of gauge reduction an additional 14% saving is possible.
- The improved product quality possible with hermetically sealed bags will help reduce food wastage caused by premature loss of shelf life.
- Integrity Seal is being offered to the market on a range of terms, outright purchase or lease purchase, and is sold as a profitable system.
- The appearance of the bag is improved, as are the opening characteristics.

7.4.2 Hermetic sealing benefits
- Air tight seals ensure there are no micro leaks, therefore headspace gas is controlled by the film permeability and not affected by leaking seals.
- High pressure sealing improves the seal strength, as verified by the tensile tests, and creases are ironed out by the embossed profile seal giving hermetic seals.
- Better temperature is possible with Integrity Seal, making it easier to handle the thinner gauge films, which the industry is moving towards.

7.4.3 Operational benefits
- The system can be retrofitted to existing machines or built into new machines.
- The seal bars or wheel assembly are simply screwed to the existing cross frames of the machine.
- The impulse bar is cold after every cycle so it is safe to touch.
- Wear components – Teflon tape and Rubber anvil - are easily and quickly replaced ensuring the seal quality is easy to maintain.
- The impulse system is immediately ready to run when it is switched on; requiring no bar heating time. Also, the low mass wheels and bars are quicker to heat than conventional cartridge heaters.
- The impulse bar does not require Teflon tape.
- Seal bar electrics are IP 65 rated.
- Temperature changes are instant with the impulse system and very quick with the low mass bars and wheels.
- The chilled water system can be centralised to feed multiple machines and positioned away from the high care area. It can also be taken from the cross seal jaws.
- The chilled water system is a closed loop system and does not use copious amounts of water.
- The chilled water has an antimicrobial additive to prevent legionella and other bacteria.

7.4.4 Product quality benefits
- Longer shelf life potential on fresh product applications due to air tight seals (as seen in the cross seal project).
- Sensitive fresh leaf salads quality improvement; no oxidation.
- Sensitive fresh leaf salads shelf life increased from 5 days to 8 days.
- For non sensitive leaf varieties e.g. spinach, shelf life can be increased from 7 days to 9 days.
- Fresh vegetables – better quality due to improved CO₂ control.
- Snack products - comparable shelf life at 12 weeks on single bag applications.
- Saves a minimum of 1% film area.
- Ensures the benefits of the hermetic cross seal system are not negated by leaking back seals.
- Integrity Seal makes hermetic seals on thinner gauge films i.e. 30 micron down from 35 micron: a further 14% reduction in packaging material usage.
- Higher line efficiency reduces total manufacturing costs.
- Integrity Seal technology seals all types of thermoplastic polymers.
- Hermetic seals on multi bag applications prevent the bag deflating over time so the product looks better on shelf.
- The embossed seal never looks overheated or blistered as can happen with flat seal bars.
8.0 Industry potential
The WRAP funded project has enabled the Integrity Seal technology to be developed for fresh produce applications but that is not the end of the story. Integrity Seal can be applied to any other product that is heat sealed in flexible packaging material on automatic and even hand sealing machines. The same system which works on vertical form-fill seal machines will work on horizontal, linear motion, flow wrapping machines. It is also possible to develop the system for use on rotary flow wrapping machines by the simple addition of rotating manifolds to feed the chilled water.

The potential for other products is considerable:

- frozen products;
- whole produce e.g. potatoes and vegetables;
- cereals;
- bakery;
- confectionery;
- biscuits;
- dairy products such as cheese;
- fresh meat and cured meats;
- soups; and
- sachet packed products, such as condiments.

In addition there are also many potential non-food applications:

- home improvement (DIY) products;
- toiletries and soaps;
- cosmetics; and
- detergents and household products.
9.0 Overall conclusions

Whilst a single technological solution had been possible in delivering the Integrity Seal for cross sealing, this had not been possible for the back seal. Differences in existing machine platforms meant that two systems had to be developed and proved; one for continuous motion machines and one for intermittent motion machines.

The objective of this project was to make an hermetic seal using a rotary heated wheel system for continuous motion machines and an impulse or constant heating system for the intermittent motion machines. A main characteristic of all the systems was the development of an embossed feature to deliver more pressure and thereby produce hermetic seals.

For the continuous motion machines, Ceetak developed an innovative heated embossed, low mass, pair of sealing rollers to deliver high pressure at a tangent to the heated wheel and hence deliver point loading. The pressure was supported by a double pair of rotary anvil wheels mounted inside the product tube.

For the intermittent motion machines, an impulse sealing technique was developed based on the same principle used for the successful cross seal project. A resistance heated system was also developed providing an alternative hot bar option.

Prototype designs were built and evaluated by Ceetak at their Bedford facility and products tested for seal strength and seal integrity. Trials and production runs took place on fresh produce at Tilmanstone Salads (Sandiacre intermittent machine) and Soleco (Ilapa continuous motion machine).

The trials were successful and demonstrated that hermetic seals were produced by both systems under production conditions. The benefits of these new technologies can be summarised as follows:

- hermetic seal;
- narrow seal profile;
- seal area reduced by 50%;
- film width reduced by 1%;
- potential film saving from using thinner gauge film of 10 - 15%;
- improved pack appearance;
- better temperature control; and
- potential improvement in product quality and shelf life.

The trials under production conditions at both Tilmanstone Salads and Soleco were the key test of the technologies and showed that with Integrity Seal it is possible to make narrower hermetic seals and hence improve pack performance.

All packs made with Integrity Seal were assessed with the penetrative dye test, vacuum immersion tank and measured for seal strength and all applications confirmed that hermetic seals are consistently achieved. In all cases the Integrity Seals were stronger than traditional technologies when measured by tensile testing.

Integrity Seal is therefore now available as a total solution for sealing bags on vertical form–fill seal machines. Several cross seal systems have already been sold beyond fresh cut prepared produce and commercial packs will be appearing in the next few months for frozen foods, whole potatoes and cereals. These installations will now be offered the appropriate back seal system.

The systems are available for commercial application across many food and non food sectors.
Appendix 1 Current sealing technology

Flat profile sealing bars and sealing bands do not always make hermetic seals on thin polymer films because the flat surfaces are rigid and do not compress the film adequately to smooth out creases evenly, leaving micro creases and leading to air leaks. Where random creases occur there will always be a leak and if one large crease or several small creases are present in any one pack, the seal integrity is compromised. The leaks, if present in sufficient number, will make it impossible to make an hermetic seal and therefore stop the film from controlling the barrier or permeability required by the product.

All heat sealing depends on temperature, time and pressure. Conventionally, a seal is made by transmitting heat through the film and with heated bars or bands this means that the inner surface to be sealed must be capable of sticking to itself without sticking to the jaw.

Back seals are typically created at a width of 10 mm in an attempt to produce an hermetic seal but in reality the width of the seal has little or no effect on integrity. Figure 9 shows dye penetrating a horizontal crease. This is a very common occurrence and is sufficient to cause loss of headspace gas control and hence compromise product shelf life. This pack was found in-store and had therefore passed the online inspections. It is very difficult to pick out such leakers as they are not easily visible to the naked eye.
The flat profile of standard seal bars, shown in Figure 10, is designed to compress the film in a controlled manner but it also creates problems. Polymer slowly builds up on the bar as a microscopic layer and if the bar is not cleaned regularly can cause the film to stick to the jaw. This causes blistering of the film in the seal area and spoils the appearance as well as impairing the seal integrity. Any product or packaging material touching the constantly heated jaws gets burnt on, requiring wire brushing.

Many machine operators use more heat than is necessary to make the perfect seal. It is the mistaken belief that the seal must be better if more heat is used. In reality, the seal gets worse when more heat is used because the molten polymer wants to run away from the heat source which leaves unsealed areas. Excessive heating causes the film to blister and stick to the seal bars so that as the bar assembly opens, the seal is weakened because it wants to remain attached to the bar. This phenomenon may not be apparent from the initial appearance of the seal but a simple dye test commonly detects areas which are not sealed.

**Figure 11** Standard flat band sealer used on continuous motion machines.

To maintain uniform heat the band has to be kept in motion, which can be dangerous. The band moves across the heated plate and picks up heat by conduction. When the complete assembly is opened up (to allow the operator to handle the packaging film down the product tube) the band is still moving. When the assembly moves forward the band makes contact with the film to make a seal. It is this initial contact which can cause horizontal creases to be formed. If the film tension is not under perfect control, or the film is sticking to the product tube, then tension is created in the film.
Appendix 2 Integrity Seal: Intermittent Motion

Two design concepts were tested during the project; a constantly heated system with double side heating and an impulse heating system, similar to the cross seal system.

Design One: The constant heat front bar

The front bar, Figure 12, is of totally different construction to the impulse seal bar. The bar is permanently heated and has the embossed pattern machined into the brass seal bar mounted on the cross assembly. A flat heated or cold anvil is located inside the product tube. The anvil is contained within a sealed cavity, separated from the product. The product tube takes on a D-shaped profile. The heated bar is of low mass to provide better temperature control.

Figure 13 shows a close up of the low mass, front seal bar mounted to the swivel bar. The view also shows the rubber anvil (in green) mounted inside the product tube. The original design included a heating element mounted behind the rubber so as to heat the film from both sides but this was found to produce little benefit. There was also some reluctance from the partners to have heaters mounted on each tube. Although the anvil and heater assembly could have been designed as a cassette and interchangeable it was considered too complex.

Figure 12 Design concept for the constant heat bar.  
Figure 13 Close up of the seal bar and anvil.
It was hoped that the unique feature of heating the film from both sides would produce a better seal and reduce the heat distortion of the outer layer of film. There may be a benefit with thicker laminates but it was of no benefit with the 35 micron films.

The drawback found with this system was the rapid wear of the rubber anvil, although this could be overcome with a finer pattern on the seal bar.
Design Two: The impulse sealing bar

The impulse heating technology was combined with innovative embossed rubber technology.

**Figure 16** The design concept for the impulse sealing system. The impulse bar is mounted vertically on the cross frame. Power terminals are positioned at the side at each end and the chilled water is fed into the back of the bar.

**Figure 17** The reverse view of the impulse bar with the side terminals.

Because the impulse bar has to be manufactured as a flat bar, the terminals must be angled to one side and far enough out to allow for the white terminal caps not to foul the film and product tube.

The surface of the impulse bar has to be flat so the embossing is produced by either moulded rubber or coarse weave Teflon tape mounted on the product tube anvil.

The seal bar, Figure 18, comprises a low mass heating element which is both narrow and thin, mounted on a stainless block which is also a chamber for chilled water. The current feed is through IP 65 rated terminal blocks at each end of the jaw. Similarly, the chilled water is fed in at the ends and circulates constantly back to the chiller unit.

When the system is triggered by a proximity probe, sensing that the bar has touched the product tube, a current is passed through the element raising its temperature very quickly to the polymer seal temperature, typically between 150 and 180 °C. The next stage of the sealing cycle involves cooling the bar to a low enough temperature, typically 80 °C, to set the seal hard. This is accomplished by the chilled water circulating behind the element. The constant flow of chilled water at around 15 °C removes the high sealing temperature within milliseconds. At each stage of the heating and cooling cycle a visual display is provided on the controller to verify the cycle has been completed.

There are a number of benefits from the cooling action. Firstly, the bar can be safely touched after every cycle so when the film has to be moved down the product tube there is no risk of burns from the bar. The second benefit is that the film is clamped during both the heating and cooling cycle eliminating any heat shrink or distortion when the bar moves back.

A further benefit is that the seal bar presses against a rubber anvil mounted in the product tube. The rubber distributes the pressure as the bar hits the product tube. The rubber can be embossed with different profiles to produce high pressure seals. Teflon tape, which has a very fine, embossed surface due to the woven mesh of the Teflon cloth, also produces a higher pressure compared with flat bars.
Integrity Seal comes with its own temperature controller which has a visual display showing the key functions of seal temperature, sealing time, cooling temperature, actual element temperature and a dynamic display of the heat application on every cycle, Figure 22.

The unit is of flexible design and can be located either attached to the existing machine panel or in a remote location. The sealing cycle starts when a signal is received from a proximity probe sensing the bar has touched the tube.
Chilled water is supplied to each machine from a centralised unit, remote from the bagging machines. The units can either be within the high care room or located in adjacent areas such as mezzanine floors or roof space.

The chilled water for the back seal, Figure 23, was taken from the existing chilled water system set up at Tilmanstone Salads for the cross seal system. This is a roof mounted system with the chiller units sited away from the high care room. Two chillers are recommended; one is operational and one is a back up in the event of a failure. The systems can be designed to feed multiple machines and supply chilled water to both the cross seal and back seal units.

Figure 22 The controller.

Figure 23 The chilled water system.

Figure 24 The control box for the chillers positioned in the high care room.
Appendix 3 Integrity Seal: Continuous Motion

The concept of this system is to replace the heated bands found in current equipment with heated wheels, Figure 25. This has the advantage that the wheel is both the heater and the means of transmitting the pressure. The low mass wheels provide more efficient heat transfer to the film and also deliver the embossed profile. As the wheels are driven from the movement of the film transport belt, they only move when the assembly moves in to start making bags. Hence they are safer because they are stationary when the frame is opened. The wheels are still heated but do not rotate when the assembly is opened, unlike bands which have to continue moving.

The narrow brass wheels push against non heated anvil rollers, which self align as they are contacted. The free rollers are not driven but pick up the motion of the film, hence there is no dragging of the film. This feature reduces the risk of creasing if the film sticks to the product tube.

Two heated wheels are provided to gently heat the film and compensate for the short dwell time. The two pairs of jockey rollers in the product tube also help support the film as it is heated, to minimise the risk of creases developing or thermal distortion.

The photographs, Figures 27-30, show the assembly without protective guarding which would normally be in place both for safety and component protection.
Figure 27 The complete drive assembly mounted on the Soleco machine.

Figure 28 The heated wheels and jockey wheels.

Figure 29 The Servo drive sensing motion of the film drive belts.

Figure 30 The servo drive for the heated wheels.
Appendix 4 Products run during the trials

**Figure 31** Soleco Florette Mixed Salad pack made on an Ilapak continuous motion machine.

**Figure 32** Soleco Florette Mixed Salad pack - close up of seal.

![Image of Soleco Florette Mixed Salad pack](image1)

**Figure 33** Marks & Spencer Iceberg lettuce bag made on a Sandiacre intermittent motion machine with the hot bar system.

**Figure 34** Marks & Spencer Iceberg lettuce bag made on a Sandiacre intermittent motion machine with the impulse system and the course weave Teflon tape.

![Image of Marks & Spencer Iceberg lettuce bag](image2)

NB – Standard width film was used for all of the back seal trials, which results in “excess” film remaining beyond the seal (as in Figures 32 and 35). This would not occur following commercial implementation of the technology, when narrower film would be used (hence realising the overall film savings and financial benefits).
Figure 35 Marks & Spencer Iceberg lettuce bag – close up of the seal.
Appendix 5 Seal integrity data

During the trials, Integrity Seals were challenged by dye testing and by vacuum immersion tank tests and in all cases samples were superior to current back seals. Figures 36 and 37 show a Marks & Spencer Iceberg lettuce and a Soleco Mixed Salad bag holding 0.5 bar with no leaks. The mode of failure for Integrity Seal packs is for the seal to burst, there are rarely any micro leaks.

The degree of vacuum that a pack will withstand is dependent on the size of the pack, the volume of the contents and the headspace volume, so direct comparisons between products is not appropriate. In general, Integrity Seal packs will withstand more than double the vacuum of a standard back seal. Tensile tests also confirmed the improved strength (see Appendix 6).

Dye testing was also used because it is a very invasive method and is non-destructive. Packs sometimes pass the vacuum test because the internal pressure forces the layers of film against each other, closing up the leaks. So the vacuum test alone cannot be used as the sole indicator of seal integrity for back seals.

**Figure 36** Marks & Spencer Iceberg Lettuce at 0.5 bar.  
**Figure 37** Soleco Mixed Salad Bag at 0.3 bar.

**Figure 38** The Marks & Spencer Iceberg lettuce bag passing the dye test.  
**Figure 39** The Soleco Mixed Salad Bag passing the dye test.
The course pattern embossed rubber (shown in Figure 20) did not always produce an hermetic seal when used with the impulse bar. This was because the bar mechanism could not deliver sufficient pressure to compress the rubber adequately. Hence channels leaks were sometimes present, Figure 40.

This did not happen with the finer pattern (shown in Figure 21). Fine embossing produced an hermetic seal, Figure 41. During the production run of 4,000 bags not a single crease was found in the back seal confirming that the improved temperature management and chilled bar stopped the thermal distortion common with the standart hot bar design.

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**Figure 40** Leaking seal in a pack sealed with coarse pattern embossed rubber.

**Figure 41** An hermetic seal in a pack sealed with the fine embossed pattern rubber.

**Figure 42** The embossed pattern made by the constantly heated bar.

**Figure 43** A crease which has been sealed hermetically by the high pressure embossing.
Appendix 6 Seal strength test data

To make a further comparison between the Integrity Seal and standard back sealing, seal strength tests were conducted. As the back seal is an overlap style it was not possible to pull the seal open horizontally because the lateral force is too great. Hence it was decided to pull open the seals by gripping the very short loose edge on the inside of the bag and tear open the seal at right angles.

Table 1 Seal strength reasons.

<table>
<thead>
<tr>
<th>Seal type</th>
<th>Machine and type</th>
<th>Average seal strength in Newton per 20 mm width</th>
<th>Seal characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard hot bar</td>
<td>Sandiacre Intermittent</td>
<td>0.04 - 0.06</td>
<td>Peals open with some delamination</td>
</tr>
<tr>
<td>I.S. HOT embossed bar</td>
<td>Sandiacre Intermittent</td>
<td>0.06 - 0.08</td>
<td>Peals open with some delamination</td>
</tr>
<tr>
<td>I.S. Impulse bar</td>
<td>Sandiacre Intermittent</td>
<td>0.12 - 0.14</td>
<td>Peals open with some delamination</td>
</tr>
<tr>
<td>Hot band</td>
<td>Ilapak continuous</td>
<td>0.04 - 0.06</td>
<td>Peals open with some delamination</td>
</tr>
<tr>
<td>I.S. Hot wheels</td>
<td>Ilapak continuous</td>
<td>0.20 - 0.28</td>
<td>No peal. Film fractures at edge of seal area</td>
</tr>
</tbody>
</table>

Figure 44 The standard hot bar seal from the Sandiacre being tested. Pealed open at between 0.04 and 0.06 N.

Figure 45 The embossed hot bar seal sample under test. Pealed open at between 0.06 and 0.08 N. Slightly increased strength compared with the standard hot flat bar.
Figure 46 The impulse, fine embossed seal under test. Pealed open between 0.12 and 0.14 N. More than twice the peal strength of the standard flat bar.

Figure 47 The hot wheel continuous motion sample under test. Seals fractures at the edge of the sealed area at between 0.2 and 0.28 N.

Figure 48 Readout from the tensile tester. Considerably stronger seals than conventional back seals.

The overall conclusion from the tensile tests was that all the Integrity Seal back seal samples were stronger than the current packs. Although the bags are never opened at the back seal it is still vital to have a strong seal which will withstand the rigorous handling during distribution and by the consumer.
Appendix 7 Ceetak seal test data

Design testing

The initial phase of the project involved using a test machine at Ceetak to prove the initial design concepts for both the intermittent systems and the continuous motion system. The main objective of this initial phase was to study the performance characteristics of different bar profiles to see which gave the best quality of seal in terms of integrity, strength and appearance.

The coarseness of the embossed patterns was assessed in terms of the ability to make hermetic seals and compared with the standard flat profiles.

A unique feature tested, was the tapered dovetail end to the seal bar. This was used in an attempt to reduce the temperature gradient at the end of the bar and so reduce the thermal distortion of the film. It was concluded that this feature did not make a significant improvement in thermal distortion and as the project progressed to using an impulse bar this feature was no longer retained.

In the case of the intermittent motion system, tests were also conducted with varying degrees of background heat delivered by a tube mounted heater, to see if any improvement in seal quality was achievable.

It was also necessary to establish if the low mass heaters were of adequate robustness to do the job.

Conclusions

The best design for the intermittent motion system comprised a fine embossed pattern in the heater bar with background heat and a flat rubber anvil. Subsequent to the Ceetak trials, it was found that this design (when tested on the Ilapack machine at Tilmanstone Salads) was not sufficiently durable as the coarse embossing was impacting too heavily on the flat rubber anvil, hence the rubber would have needed frequent changing. It was therefore decided to employ an impulse bar and transfer the embossing to the anvil side. This combination was very successful and became the preferred design for all intermittent motion systems.

The improved temperature control with all the systems reduced the risk of over heating the film. The low mass components with all systems actually performed very well with start-up times reduced by 10 minutes.

The best design for the continuous hot wheel system featured knurled brass wheels with jockey rollers mounted in a cavity inside the product tube. The initial idea of using a heated band inside the product tube and friction to drive the embossed wheels was not effective so it was decided to include servo drives to both the wheels. This was very effective and meant that there was no longer any need to drive a heated band in the product tube. A pair of jockey rollers inside the tube were then used to provide the tangential force to make a heat seal. This design was very effective and produced excellent seals.

Test data from the initial trials at Ceetak on the Line Equipment Machine

Intermittent Motion Back Seal

In the initial phase of the project, a number of designs were proposed for testing in various combinations. Three types of heater were mounted in the product tube, designated types 1, 2 and 3 and seven designs of front heater bar designated types 1 to 7. For clarity, the results table only shows the data which gave acceptable seals. Type 3 heater in the product tube and types 4 to 7 for the front bar gave the best results with type 7 having a wider tolerance of temperatures. The green cells in the table highlight the optimum conditions established for this combination. Type 7 seal bar and type 3 rear heaters were therefore selected for the trials at Tilmanstone Salads.

Rear heat

To improve control of the back seal quality a heater bar is fitted in the front section of the product tube. The heater bar is a low mass, quick acting, accurate temperature control type.
Types used as listed below:

Type 1: Flat heater bar  
Type 2: Flat heater bar with single layer of heat conductive rubber  
Type 3: Flat heater bar with double layer of heat conductive rubber

Front heat

The traditional (front) heater bar has been replaced by a heater bar with more accurate temperature control. Different profiles were used as listed below.

Type 1: 5mm radius sealing face  
Type 2: 8mm radius sealing face  
Type 3: 45° grooves at 5mm pitch in sealing face  
Type 4: Small grooves in between type 3 grooves  
Type 5: All grooves same size  
Type 6: Coarse knurled pattern on sealing face  
Type 7: Fine knurled pattern on sealing face

Additional features: Dovetail fitting on the end of blade to ensure overlap of seal.

Seal quality score index

<table>
<thead>
<tr>
<th>Seal score</th>
<th>Colour code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - Ignored</td>
<td></td>
</tr>
<tr>
<td>1 - No seal</td>
<td></td>
</tr>
<tr>
<td>2 - 25% seal strength</td>
<td></td>
</tr>
<tr>
<td>3 - 50% seal strength</td>
<td></td>
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<tr>
<td>4 - 80% seal strength</td>
<td></td>
</tr>
<tr>
<td>5 - 90% seal strength</td>
<td></td>
</tr>
<tr>
<td>6 - 95% seal strength</td>
<td></td>
</tr>
<tr>
<td>7 - 100% seal strength with more than 2 leaks</td>
<td></td>
</tr>
<tr>
<td>8 - 100% seal strength with no more than 2 leaks</td>
<td></td>
</tr>
<tr>
<td>9 - 100% seal strength with no more than 1 leak</td>
<td></td>
</tr>
<tr>
<td>10 - 100% seal strength and hermetrical seal</td>
<td></td>
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</tbody>
</table>

Table 2 Intermittent seal test data.

<table>
<thead>
<tr>
<th>Intermittent motion settings</th>
<th>All results are for the type 3 heater mounted in the product tube</th>
<th>Seal Temperatures C</th>
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</thead>
<tbody>
<tr>
<td>Front bar heater</td>
<td>AMBIENT</td>
<td>60</td>
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<td>Type 1</td>
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<td></td>
<td>239</td>
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<tr>
<td>Type 7</td>
<td></td>
<td>248</td>
</tr>
</tbody>
</table>

Seal score

Colour code: 10
Continuous Motion Back Seal

In the initial phase of the project, three basic designs were proposed for testing; designated Types 1, 2 and 3. All designs featured a heater placed in the product tube to heat the inside of the back seal overlap. Other design features included different methods of heating the film from the front, a continuous band or wheels. The wheel profiles also varied between a curved shape and knurled profiles. All three types were tested and comparisons made of the seal quality. The table of results clearly shows that type 3 delivered the best seal quality. The results only show data for type 3 as types 1 and 2 did not produce acceptable seals. This design was used on the subsequent trials at Soleco with the addition of a stepping motor to improve the film drive.

Rear heat

To improve control of the back seal quality, a heater bar is fitted in the front section of the product tube. The heater bar is a low mass, quick acting, accurate temperature control type.

Types used as listed below:

Type 1: Flat heater bar fitted with rotating seal band
Type 2: Individual silicon rubber wheels
Type 3: Individual silicon wheels with background heat

Front heat

Free wheeling, individually heated wheels mounted in front of the product tube and aligned with the heated bar mounted within the product tube.

Sealing wheel profiles

Type 1: Free wheeling 75mm diameter twin heated wheels with 5mm radius sealing face
Type 2: Free wheeling 75mm diameter coarse knurling on sealing face
Type 3: Free wheeling 75mm diameter fine knurling on sealing face

Later, wheels were driven via a stepper motor and control system to minimise drag on the film.

Seal quality score index

<p>| | | | | |</p>
<table>
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<td>100% seal strength and hermetical seal</td>
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Table 3 Continuous seal test data.

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<td>175</td>
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Type 2 75mm dia coarse knurling

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Development of “Integrity Seal” Back Sealing Technology
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**Type 3 75mm dia fine knurling**

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Appendix 8 Packaging savings from using Integrity Seal technology

**Illustrative packaging savings using back seal for fresh produce.**  
(Calculations based on a typical fresh salad \ vegetable bag).

Saving from using narrower film (1% saving).

<table>
<thead>
<tr>
<th>Description</th>
<th>Original size</th>
<th>New size</th>
<th>Saving</th>
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</thead>
<tbody>
<tr>
<td>Original wrap size:</td>
<td>460mm * 272mm</td>
<td>460mm * 272mm = 0.1251 m²</td>
<td>0.0013 m² or 1.04%</td>
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<tr>
<td>New wrap size:</td>
<td>455mm * 272mm</td>
<td>455mm * 272mm = 0.1238 m²</td>
<td>0.0013 m² or 1.04%</td>
</tr>
<tr>
<td>One original wrap @</td>
<td>0.1251 m²</td>
<td>0.1238 m² weighs 4.533 g</td>
<td></td>
</tr>
<tr>
<td>One new wrap @</td>
<td>0.1238 m²</td>
<td>0.1238 m² weighs 4.486 g</td>
<td></td>
</tr>
</tbody>
</table>

Saving per wrap is therefore 0.047 g.  
Saving per million bags is therefore 47 kgs or 0.047 tonnes.

Estimated number of fresh produce bags made per year: 10.5 million bags per machine per year.

Assuming a minimum of 112 machines in the fresh produce industry in the UK this makes the annual pack volumes 1,176 million.

**Based on 1,176 million bags the saving is 55.27 tonnes of film per year**

Additional weight saving from using thinner gauge film (14.29 %).

Calculations based on reducing the film gauge from 35 micron to 30 micron.

One new narrow wrap in 35 micron film @ 0.1238 m² weighs 4.486 g.

Therefore with a weight reduction of 14.29% of the new weight will be 3.845 g giving a saving of 0.641 g per pack. Weight saving per million bags is therefore 641kgs or 0.641 tonnes.

**Based on 1,176 million bags the saving is 753.82 tonnes of film per year**
Illustrative packaging savings using both cross seal and back seal for fresh produce
(Calculations based on a typical fresh salad \ vegetable bag).

Saving from using shorter bag (cross seal) (10 – 15% area saving).
Saving from using narrower film (back seal) (1% saving).

Original wrap size: 460mm * 272mm = 0.1251 m²
New wrap size: 455mm * 240mm = 0.1092 m²
Saving: 0.0159 m² or 12.75%

One original wrap @ 0.1251 m² weighs 4.533 g.
One new wrap @ 0.1092 m² weighs 3.957 g.

Saving per wrap is therefore 0.576 g.
Saving per million bags is therefore 576 kgs or 0.576 tonnes.

Estimated number of fresh produce bags made per year: 10.5 million bags per machine per year.

Assuming a minimum of 112 machines in the fresh produce industry in the UK this makes the annual pack volumes 1,176 million.

Based on 1,176 million bags the saving is 677.38 tonnes of film per year

Additional weight saving from using thinner gauge film (14.29 %).
Calculations based on reducing the film gauge from 35 micron to 30 micron.

One original wrap in 35 micron film @ 0.1251 m² weighs 4.533 g.

Therefore with a weight reduction of 14.29% the new weight will be 3.885 g giving a saving of 0.648 g per pack. Weight saving per million bags is therefore 648kgs or 0.648 tonnes.

Based on 1,176 million bags the saving is 762.05 tonnes of film per year

Total combined savings are therefore 1,439.43 tonnes
www.wrap.org.uk/retail