light to certain forms of advertising campaigns rather than facilitating informed choice.

The argument that there is no need to separate out the GM soy because it is designated safe, and equivalent, by the regulatory authorities, may be valid on safety grounds, but consumers could perceive that Big Business is playing Big Brother, and that they are being coerced into acceptance by removal of consumer choice. The voluntary provision of information in response to consumer interest – including labelling where this makes sense – is being encouraged, and may yet become a legal requirement. Certainly, many large food chains have taken this responsibility to their customers seriously, and have invested in providing simple, but accurate information on the process of genetic engineering and what this means in terms of product safety and nutritional quality. Consumer surveys are reported to show a slightly increased acceptance of foods made from GM plants and animals among consumers with a greater knowledge of genetic modification[11].

However, provision of information can go only so far. To help ensure their views are heard, more consumers should make use of such information to familiarize themselves with the science, concepts and issues. A better understanding will enable consumers to discriminate between fact, commercial hype and sensationalist scare stories, and to demand the answers they need to pertinent questions. Consumers and their spokespeople therefore also have a responsibility to themselves to ensure they are making an informed choice.

Education and familiarity with GM products may eventually enable consumers to accept these arguments, but the introduction of GM products without adequate consideration of consumer concerns may have been premature. Maybe the old adage 'the customer is always right' should be remembered.

References

1 DoE/ACRE Public Register (7 January 1997) *Index of Public Register Entries for Applications to Market GMOs Under Directive 90/220*, Department of the Environment Biotechnology Unit, London, UK

2 Campden & Chorleywood Food RA (1996) *Biotech Club Bulletin, No. 2*, Campden & Chorleywood Food RA, Chipping Campden, UK

3 Monsanto Agriculture (1996) *Herbicide Use Today and After the Introduction of Roundup Ready™ Soybeans*, Monsanto Europe, Brussels, Belgium

4 Monsanto Agriculture (1996) *The Life of a Soyabean: The Diverse, Complex Path It Can Take*, Monsanto Europe, Brussels, Belgium

5 The Advisory Committee on Novel Foods and Processes (1996) *The Use of Antibiotic Resistance Markers in Genetically Modified Plants for Human Food: Clarification of Principles for Decision Making*, ACNFP, c/o Ministry of Agriculture, Fisheries and Food, London, UK

6 Webb, V. and Davies, J. (1994) 'Accidental Release of Antibiotic-resistance Genes' in *Trends Biotechnol.* 12, 74–75

7 Food Advisory Committee (1996) *Press Release, 19 December 1996*, p. 2, UK Food Advisory Committee, London, UK

8 Anon. (1997) 'Europeans Labelling US Soybeans' in *Biotech Reporter* January, 1–2

9 Polkinghorne, J. *et al.* (1993) *Report of the Committee on the Ethics of Genetic Modification and Food Use*, Her Majesty's Stationery Office, London, UK

10 Frewer, L., Howard, C. and Shepherd, R. (1997) 'Public Concerns in the United Kingdom About General and Specific Applications of Genetic Engineering: Risk, Benefit and Ethics' in *Sci. Technol. Hum. Values* 22(1), 98–124

11 Consumers' Association and Scottish Consumer Council (1996) *Joint Position Paper 'Genetically Modified Soya in the UK – Consumer Concerns'*, Scottish Consumer Council, Glasgow, UK

EHEDG Update

Hygienic pipe couplings

This paper, the 18th in a series of EHEDG Updates to appear in TIFS, presents an extended summary of newly released guidelines for ensuring the hygienic design of pipe couplings for use in food processing equipment. The guidelines, recommended by the Pipe Couplings subgroup of the European Hygienic Equipment Design Group and approved by the EHEDG, identify design parameters necessary to produce pipe sealing systems that are easy to clean or sterilize in-place, and are bacteria tight, reliable and easy to install. The EHEDG is an independent consortium formed to develop guidelines and test methods for various aspects of the safe and hygienic processing of food; the group includes representatives from research institutes, the food industry, equipment manufacturers and government organizations in Europe*.

*Readers requiring further information on the EHEDG are referred to *Trends in Food Science & Technology* (1992) Vol. 3(11), p. 277.

Pipe couplings are the most frequently used elements of modern food processing equipment. Wherever connections are made between plant elements (e.g. pumps, valves, filters, vessels), a dismountable joint creates possibilities for maintenance, quick replacement, or changes in the processing sequence or product flow route.

Because pipe couplings are typically mass produced, they were among the first items to be standardized. The basic designs specified in the most important standards currently used in Europe[1,2] are now 30–35 years old. As the development of products and processing methods has resulted in more sensitive products and more severe process conditions, in many cases pipe couplings are operating at the limit of their capabilities, with increasing risk of failure from hygienic as well as mechanical points of view.

This increasing risk and the related failures have prompted equipment users and manufacturers to design improved couplings. Thus, almost every major equipment supplier now has their own type of coupling, reducing equipment versatility and increasing costs to users and manufacturers.

PII: S0924-2244(97)01020-0

For this reason the EHEDG instituted a subgroup on Pipe Couplings to study the problems and prepare recommendations that may lead to satisfactory standards.

Remit and objectives of the subgroup

The objectives of the subgroup were to identify and define design parameters for sealing systems for dismountable welded pipe couplings that have the following characteristics:

- easy to clean in-place;
- sterilizable in-place;
- impervious to microorganisms;
- easy to install;
- reliable.

The subgroup has specified 'reliability' as:

- resistant to processing conditions between −10°C at 25 bar and 120°C at ≤120 bar;
- resistant to steam sterilization at 140°C at an overpressure of 3 bar for 20 min;
- compatible with and resistant to product media and chemicals used for cleaning and sterilization;
- bacteria tight under all temperature and pressure conditions mentioned above;
- having a useful lifetime of ~1 year.

For a list of definitions of other terms used, please see Ref. 3.

Sealing: basic principles of bacteria tightness

Making a joint impervious to microorganisms is relatively easy if one understands the basic principles of static sealing. As the objective is to prevent the retention of product soils and the passage of microorganisms, there must be no passageways in the joint through which microorganisms can pass.

The EHEDG recommends a maximum surface roughness value of 0.8 μm R_a (32 μin RMS, or ~4 μm R_z) for the sealing faces of coupling parts.

If the surface profile is too rough, 'valleys' in the surface will allow the passage of bacteria and thus need to be filled; an elastomer gasket pressed onto the surface is commonly used. A minimum contact pressure of 1.5 N/mm^2 is required when using a 70° Shore A hardness elastomer; this is obtained when the gasket is compressed by 15% of its original thickness.

Critical design parameters

When designing a static seal using an elastomer gasket, several characteristics have to be considered very carefully. These are summarized in Box 1.

Resilience

Resilience is undoubtedly the most important characteristic. A resilient gasket will maintain a high enough pressure on the metal sealing faces of a coupling to ensure reliable bacteria tightness. In the case of most elastomers, there is a direct relationship between hardness and resilience. Loss of resilience is mainly caused by ageing, which is a slow vulcanization process. Although manufacturers take measures to retard ageing, it cannot be prevented.

The main factors that promote ageing are temperature and deformation. Because the operating temperature is usually a given factor, the only measure that can be taken is to ensure that the gasket is exposed to the heat source as little as possible and that heat flux is diverted away from the gasket.

Deformation of the gasket can be influenced by the design of the joint. It is recommended to limit the compression rate to 20–25%, by careful design, to achieve an acceptable degree of reliability.

Gasket surface condition

Because the gasket is in direct contact with the product, the surface must be cleanable. Assuming that the elastomer has appropriate chemical and thermal resistance, two parameters can adversely influence gasket cleanability: the presence of pores, and the development of cracks.

Pores may result from the surface roughness of the mould used to produce injection-moulded gaskets. The surface roughness should be as low as possible. It is recommended that gaskets be produced by experienced manufacturers only.

Box 1. Summary of critical design parameters

Critical design parameter	Recommendation
Resilient gasket material	Use elastomer gaskets 70° Shore A
Surface roughness	Metal faces ≤0.8 μm R_a Gasket surface as smooth as possible
Contact pressure	Minimum 1.5 N/mm^2 Maximum 2.5 N/mm^2
Pores at product-contact surface	Metal parts: no pores Gasket: no pores >1 μm
Friction	Avoid sliding during compression Develop low-friction elastomers
Expansion rate of elastomers is 15-fold that of stainless steel	Minimize elastomer volume Make bi-directional expansion possible
Elastomers are not compressible, but can be deformed	Allow room to accommodate deformed gasket
Recess of gasket at product side	≤0.2 mm
Protrusion of gasket at product side	≤0.2 mm
Stress in elastomers	Avoid tensile stress Limit compression to 20–25%
Tolerances	Critical areas: Location of coupling halves Compression of gasket Inside diameters
Damage to sealing faces	Protect faces against damage

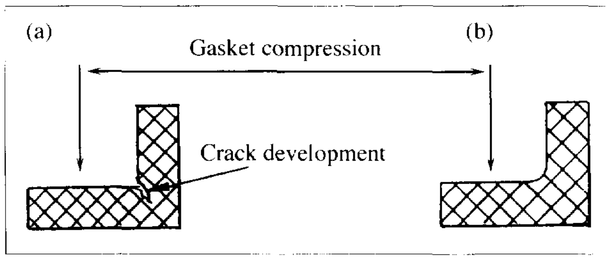

Fig. 1
Sharp corners may cause cracks (a); these can be prevented by a rounded design that gives gradual transition from high to low stress (b).

Avoiding locating the split line of the mould at the product-contact surface of the gasket is also very important. In some cases, removal of the resulting burrs by grinding or blasting affected the integrity and cleanability of the surface.

Surface compressive stress in the gasket during moulding and curing must be obtained by optimal mould design and/or controlled injection pressure to prevent the formation of an unacceptable number of open pores.

It should be ensured that any plasticizers or accelerators present in the elastomer, which may be transformed into gas (peroxide) bubbles, do not result in pores on the surface of the gasket.

When designing a gasket, care must be taken to minimize tensile stresses that occur at the product-contact surface as a result of deformation and thermal expansion, because stress promotes elastomer oxidation.

Development of cracks

Cracks will develop not only when excessive tensile stresses are present, but also when the gasket geometry results in large differences in compressive stress (Fig. 1). Making the transition from high to low stress more gradual can prevent crack development.

Surface damage due to friction

The coefficient of friction between stainless steel and elastomers can be as high as 0.3 under dry conditions, which may result in shear damage to the gasket surface when the gasket expands sideways during compression.

If a lubricant is used, the friction factor may be reduced by a factor of 15; however, this is not practical because the unevenly distributed friction makes it very difficult to control the shape and position of the gasket when compressing it between stainless steel surfaces. A better solution would be to develop a suitable low-friction elastomer.

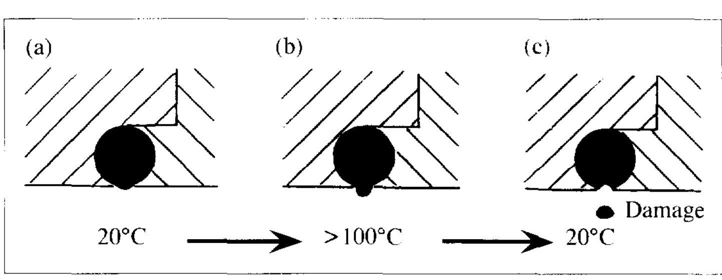

Fig. 2
Damage to an O-ring gasket due to thermal effects. If the temperature is raised from 20°C (a) to >100°C (b), the volume of the O-ring increases more than the volume of the stainless steel groove in which it is enclosed. Thus, elastomer extrudes through the gap between the male part and the liner. Theoretically, it will retract to its original position when the temperature is lowered, but friction, loss of resilience and the sharp edges of the gap may damage the surface (c).

Dynamic behaviour of static seals

Thermal expansion

The thermal expansion of elastomers may be as much as 15-fold greater (for silicone rubber) than that of stainless steels. If thermal expansion is not properly considered, the gaskets may be seriously damaged, making them unfit for cleaning in-place and possibly contaminating the product with small pieces of elastomer (Fig. 2).

The effects may be reduced by selecting a smaller-sized gasket, or by providing the possibility of expansion to the non-product side. When doing so, care must be taken to ensure that product pressure will not force the gasket into this expansion recess. The area of the gasket that is exposed to product must be kept as small as possible.

Deformation of the gasket due to exterior forces

Elastomers can be deformed, but their volume cannot be reduced. This means that when a flat gasket is compressed so that the thickness is reduced by say 20%, that the width of the gasket is increased by 25%, assuming that the length can be kept constant.

As a consequence, a considerable amount of movement occurs at the edges of the gasket. In view of the inconsistency of the friction between stainless steel and elastomers, it is extremely difficult to predict how the gasket will deform.

To minimize these undesirable effects, it is recommended that the width of the compressed part of a gasket is reduced as much as possible and that possibilities for its expansion in two directions are provided.

A further possibility to reduce the effects of friction is to avoid even compression of the gasket by using a profiled section that 'involutes' along the sealing faces rather than sliding under compression (Fig. 3).

Manufacturing tolerances

Manufacturers tend to use wide tolerances, which reduce production costs. However, the requirement for easy cleanability requires a smooth joint, and thus tolerances that are as tight as possible.

By performing cleaning tests we determined that, if the inside diameters of the couplings differed by ≤0.4 mm, cleanability was not affected. The width of the gasket is not very critical, provided it is in the range 1–4 mm. For a threaded coupling to meet the requirements of in-place cleanability, the misalignment must be ≤0.2 mm.

Identification

It is important that couplings can be identified. If the material can be identified by a marking on the related parts, it will not only allow the cause of problems to be traced, in case of failures, but it will also help to avoid problems due to errors when parts are taken from stock.

Current techniques allow the marking of metal parts in such a way that there are no adverse effects. The marking of elastomer parts is more difficult because the marking has to be integrated into the mould. This results in an embossed marking which, if situated in a critical area, may affect the proper functioning of the part. Specially designed profiled gaskets can most easily incorporate a marking.

It is recommended that the following information is marked on coupling parts: manufacturer, material, size, pressure limit (metal parts only) and temperature limit (gasket only). It is also recommended that manufacturers are certified (e.g. to ISO 9001) to ensure consistent quality.

Design of a sealing system using the 'critical design parameters'

The designs shown in Fig. 4 were made taking into account the critical design parameters described above and summarized in Box 1.

The main features are:

- The gasket material cannot be overstressed owing to mechanical limitation of the deformation of the gasket. Maximum deformation is 20% at the product interface.
- The volume of the functional part of the gasket is minimal to limit the effects of thermal expansion. The sectional area of the seal lip is only 3.2 mm^2, which equals that for a 2-mm O-ring.
- Only a small area of the gasket is exposed to the product (the gasket width is only 1 mm).
- To give the gasket some stiffness to assist handling, it has a solid shoulder, which has room for expansion. This allows the small functional part of the gasket to expand in two directions. To prevent air being trapped between the gasket shoulder and the male-part groove, small slits are provided on the outside, to act as vents.
- The solid shoulder offers excellent possibilities for identification.
- Offset of the male part and the liner is prevented by a minimum-tolerance design.
- The gasket is press-fitted into the recess of the male part, preventing it from dropping out.
- The rather sharp sealing faces are well protected against impact damage because they are situated in a recess in the metal coupling parts.

A prototype of this coupling has been designed and manufactured by APV-Rosista (Unna Königsborn, Germany). Tests showed that the design complied with all requirements, and clearly showed the importance of a smooth surface for the cleanability of the gasket.

Design of a sealing system using an O-ring gasket

The design of a sealing system using an existing gasket and still meeting the requirements of cleanability, sterilizability and reliability is difficult. Because the shape of the gasket is a given factor, design freedom is limited. The only variables available are the size of the gasket and the geometry of the sealing faces.

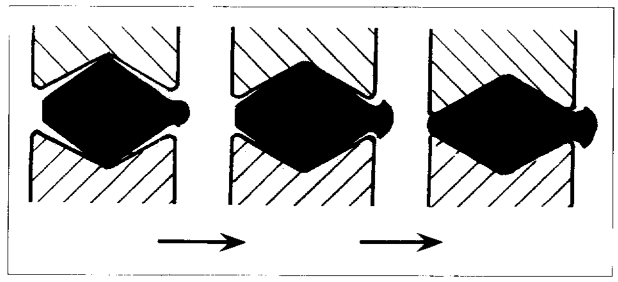

Fig. 3
'Involution' of the gasket during compression.

Size of the gasket

Experience from testing O-ring gaskets at limiting temperatures shows that most damage is suffered as a result of thermal expansion and shrinkage of the gasket. Comparison of thermal effects on O-rings with a diameter of 5.0 mm or 3.55 mm showed that the larger-diameter O-ring clearly experiences a lower percentage volume deviation. Other reasons to prefer a thicker gasket are better mechanical stability, and easier manufacture when narrow tolerances must be applied. An O-ring joint in which the usual temperature stress and cleanability problems were avoided has been designed by Tuchenhagen (Büchen, Germany) using finite element analysis.

Standardization

One of the objectives of the EHEDG is to advise international standards organizations with respect to the standardization of hygienic equipment. The intention of the subgroup on Pipe Couplings is to use the results of its efforts for a European standards proposal.

In view of demands by the German industries for a pipe coupling with superior hygienic and aseptic characteristics,

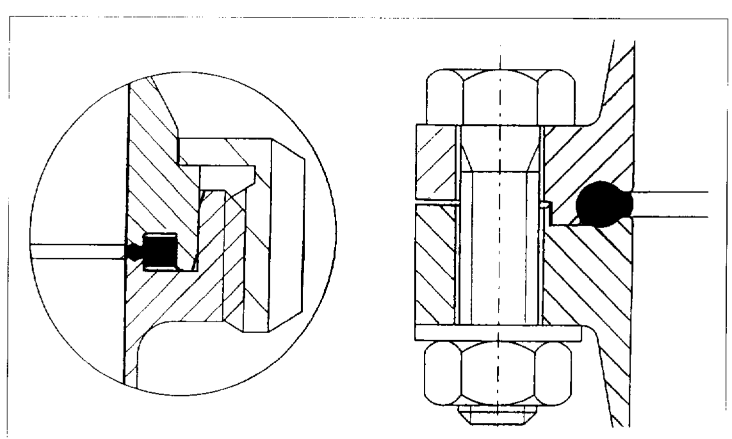

Fig. 4
Proposed coupling designs that take into account all of the critical design parameters identified. See text for details.

cooperation between the EHEDG and the related German standards organization Deutsches Institut für Normung (DIN) has been established. The proposals by the EHEDG subgroup have been accepted, and standards proposals have been developed for both the APV-designed profiled gasket and the Tuchenhagen-designed O-ring gasket, in a screwed-coupling version (DIN 11861-1) and a flanged version (DIN 11861-2). Both proposals will be ready for public comments early in 1997.

Further presentation of the standards to international standards organizations such as the CEN and ISO must be left to the DIN. EHEDG members may also be requesting their respective national standards organizations to support the presented proposals.

Acknowledgements

The authors gratefully acknowledge the contributions of members of the 3-A Steering Committee, resulting from cooperation between this organization and the EHEDG.

This paper presents an extended summary of the guidelines recommended by the European Hygienic Equipment Design Group (EHEDG) subgroup on Pipe Couplings. Copies of the full report, by F. Baumbach, J.P. Dubois, W. Grell, H.R. Goodfellow, G. Hauser, A.G. Hendriks, D. Nanz, J.A.A.M. van der Pol, S. Thomaschki, D.A. Timperley and S. Zahrer, are available from the EHEDG Secretary: J.T. Holah, Campden & Chorleywood Food Research Association (CCFRA), Chipping Campden, UK GL55 6LD (tel. +44-1386-842041; fax: +44-1386-842100).

References

1 DIN 11851 (1963) *Rohrverschraubung aus Nichtrostenden Stahl*, Deutsches Institut für Normung, Beuth Verlag GmbH, Berlin/Köln, Germany

2 ISO 2853 (1976) *Stainless Steel Screwed Couplings for the Food Industry*, International Organization for Standardization

3 EHEDG (1993) 'Hygienic Equipment Design Criteria' in *Trends Food Sci. Technol.* 4, 225–229

Conference Report

1st European Symposium on Enzymes in Grain Processing*

Robert Muller

My small son was very excited when he heard that I would be visiting The Netherlands: he hoped that I would meet Peter Pan. Although a little confused by this, I promised to let him know if I did. I certainly met many other people, because the meeting was well attended by some 130 participants.

The roles of pentosans and pentosanases in baking is clearly a 'hot topic' at the moment: at least 10 of the 26 presentations given at the meeting were on this theme, and related cell-wall issues. The pentosans are non-starch polysaccharides, being linear polymers of the pentose xylose, with branches of the pentose arabinose. The arabinose can then be crosslinked via ferulic or coumaric acids to other cell-wall constituents such as protein. Although they account for only 2–3% of the wheat grain by weight, pentosans are responsible for absorbing 20–30% of the available water during dough mixing. This is then released during baking, causing related problems. The pentosanases are a diverse group of enzymes that degrade pentosans and not only alleviate these problems but also, in some cases, actually enhance bread quality. It is, however, unclear which pentosanases are best suited to baking and how they achieve this enhancement.

Endogenous enzymes in wheat

Thus, one of the highlights of the meeting was provided by G. Beldman (Wageningen Agricultural University, The Netherlands), who offered a detailed examination of the modes of action of some microbial and endogenous arabinoxylan-degrading enzymes. Working with the different enzymes of *Aspergillus* spp., he was able to translate the reaction products obtained into an understanding of the sites of action of the different enzymes. Thus, endoxylanases I, II and III act at different sites to produce different products. Type-II endoxylanases were considered likely to be most useful during baking. Type-III action results in an increase in viscosity followed by a decrease, whereas Type-I action degrades pentosans without any preliminary viscosity increase due to solubilization. Although all the tissues

*Held in Noordwijkerhout, The Netherlands, 2–4 December 1996

Robert Muller is at BRF International, Lyttel Hall, Nutfield, Redhill, UK RH1 4HY (fax: +44-0-1737-822747).

PII: S0924-2244(97)01000-5