Neutral Citation Number: [2012] EWHC 1147 (Comm)

Case No: 2009 FOLIO 871

IN THE HIGH COURT OF JUSTICE
QUEEN'S BENCH DIVISION
COMMERCIAL COURT

Royal Courts of Justice
Strand, London, WC2A 2LL

Date: 01/05/2012

Before :

MR JUSTICE CHRISTOPHER CLARKE

- -

Between :

(1) KINGSPAN ENVIRONMENTAL LIMITED **(2) TYRRELL TANKS LIMITED** **(3) ROM PLASTICS LIMITED** **(4) TITAN ENVIRONMENTAL LIMITED**	**Claimant**
- and -	
(1) BOREALIS A/S **(2) BOREALIS UK LIMITED**	**Defendant**

- -
- -

Mr Justin Fenwick QC, Ben Elkington, Brendan McGurk and Katie Powell (instructed by **Arthur Cox**) for the **Claimants**
Mr David Allen QC, James Brocklebank, Sushma Ananda and Elizabeth Lindesay (instructed by **Kennedys**) for the **Defendants**

Hearing dates: **May** 9th, 12th, 13th, 16th, 17th, 18th, 19th, 20th, 23rd, 24th, 25th, 26th, 27th; **June** 7th, 8th, 9th, 10th, 13th, 14th, 15, 16, 17th, 21st, 22nd, 23rd, 24th, 27th, 28th, 29th, 30th; **July** 4th, 5th, 6th, 7th, 8th, 11th, 12th, 13th, 14th, 15th, 19th 20th, 21st, 22nd, 25th, 27th, 28th and 29th **2011**

- -

Judgment Approved by the court for handing down (subject to editorial corrections)

MR JUSTICE CHRISTOPHER CLARKE:

Introduction

1. In this action the claimant companies claim damages of the order of £ 40 million, originally put at around £ 100 million, in respect of the supply to them by the defendants of a polymer known as Borecene. The claimants used Borecene as the raw material with which to rotomould static tanks to hold bulk liquids, in particular kerosene. The tanks come in five basic styles - Bunded, Horizontal, Rectangular (Slimline), Low Profile and Vertical - with different designs in each style. A bunded tank is a single skin tank housed in an outer tank to prevent leakage into the ground.

2. A substantial proportion of the oil tanks manufactured from Borecene supplied to the claimants in 2002-3 have failed. From late 2003 onwards complaints began to come in that oil tanks made from Borecene were cracking (a few had begun to deform) and leaking. These failures were in much greater numbers and at a higher rate than had been the case in respect of the type of resin previously used.

3. The claimants contend that the failures of their tanks made from Borecene are the consequence of breaches of the contracts for the sale of that product to them, and that their losses are also attributable to misrepresentations which were made to them about its characteristics. In essence they say that the Borecene supplied was not fit for the purpose of making static oil tanks because it had inadequate resistance to ultra violet light ("UV") either because of its intrinsic characteristics or its inadequate stabilisation package or a combination of the two.

4. The defendants say that Borecene is neither unsuitable nor unfit for purpose and has certainly not been shown to be so. The tank failures arose from the claimants' inability or failure properly to use Borecene and to ensure that it could make satisfactory tanks taking account of Borecene's different rotomoulding properties of which they were aware. They also contend that the issues in this case are to be determined by the law of Denmark and that any liability they may have is severely limited by the terms of the relevant contracts.

5. The parties have swamped the court with a vast amount of material, which they have been preparing over several years. The factual statements are many and long. Experts'

reports have been filed of considerable complexity and inordinate length, with voluminous appendices and considerable repetition or overlap. A large number of experiments have been carried out. The claim for misrepresentation as pleaded appears to cover practically everything said by Borealis to the claimants about Borecene over an extended period. Much of the misrepresentation case has been abandoned.

6. The inordinate size of the material and the scatter gun approach adopted, particularly by the claimants, is an enemy to understanding. In order not to make what will be a long judgment interminable, I propose to confine it to the critical areas. I shall not attempt a summary of all the evidence. What follows are my conclusions from the totality of the material, factual and expert, adduced by each side. I have been much assisted by the final submissions of both parties, which have helpfully directed me to the matters that in the end the parties regarded as significant. I have reconsidered all the evidence to which those submissions make reference whether or not I have expressly referred to it in this judgment.

7. In the earlier case of *Balmoral Group Ltd v Borealis UK Limited, Borealis AS and Borealis A/S* [2006] EWHC 1900 (Comm) Balmoral claimed (unsuccessfully) in respect of the failures of its oil tanks made from Borecene. The claim in those proceedings was that Borecene had inadequate environmental stress cracking resistance ("ESCR"). Environmental Stress Cracking is the cracking of a polyethylene part under stress when in contact with a medium, e.g. kerosene, in the absence of which fracture does not occur under the same conditions of stress. No claim was made in that case in respect of inadequate UV resistance. Nor has any other claim been made against Borealis on that basis.

The parties

8. The claimants (as now named) are:

i) Kingspan Environmental Ltd;

ii) Tyrell Tanks Ltd;

iii) Rom Plastics Ltd; and

iv) Titan Environmental Ltd.

Some of these companies and their holding companies have gone through a series of name changes.

The first claimant – Titan

9. Kingspan Environmental Ltd was previously called Plashapes Ltd (6 July 1984 – 13 August 1999) and then Titan Environmental Ltd (13 August 1999 to 10 September 2008). For the purposes of this action it is convenient to describe it as "Titan", the name which it had for most of the time with which this action is concerned. It is the principal UK trading company of, and became part of, the Kingspan Group, of which the ultimate holding company is Kingspan Group Plc, when its then ultimate parent

company – then known as S & D Management Ltd ("S & D")[1] - was acquired by the Kingspan Group on 11 March 1996. At the material times its manufacturing site was at Banbridge, County Down. It is now based in Portadown.

The second claimant – Tyrell

10. The second claimant is, and at all material times has been, named Tyrell Tanks Ltd. It, too, became part of the Kingspan Group upon the acquisition of S & D in March 1996. It manufactured tanks at a site in Portadown, County Armagh. Its business and assets were transferred to the first claimant as from 1 January 2007.

The third claimant – Rom

11. The third claimant is, and always has been, Rom Plastics Ltd. It became part of the Kingspan Group in 1997[2]. It was a small manufacturing and sales company carrying on business from its site in Glenamaddy, County Galway, ROI. In 2003 its business and assets were transferred to the fourth claimant. Until its business was fully transferred it continued to purchase Borecene for use by itself or the fourth claimant and continued with the manufacture of oil tanks.

The fourth claimant – GSP

12. Titan Environmental Ltd was previously called Kingspan GSP Ltd, its name between 5 December 1989 and 7 June 2005. Before that it was called General Steel Products Ltd. It is convenient to call it GSP. It was acquired by the Kingspan Group in March 1996 on the acquisition of S & D, its then parent. It is the principal ROI trading company in the group. It carries out tank manufacturing from its site at Carrickmacross in the ROI.

13. The relevant details of the claimant companies, all of which have Kingspan Group Plc as their ultimate holding company, and the names which I propose to use in respect of them in this judgment, when it is necessary to distinguish them are, thus, as follows:

Name	**Domicile**	**Factory Location**	**Function**
Titan	N.I.	Banbridge	Principal UK trading company selling to the UK other than NI.
Tyrell Tanks	N.I.	Portadown	Tank manufacturing company.
ROM	Eire	Glenamaddy	Small manufacturing and sales company.
GSP	Eire	Carrickmacross	Principal RoI trading company.

14. Another member of the Kingspan Group of Companies was Plastics Development Centre (PDC). This company operated as the research and development arm of the Kingspan companies. Its personnel included Dr Julia McDaid ("Dr McDaid"), who had a Ph.D. in the field of rotomoulding and an M.Sc., in Polymer Science and Engineering, and Mr Dessie Gregg.

[1] S & D was later re-named Kingspan IBC Ltd, then Kingspan Environmental Containers and then Kingspan Environmental & Renewables Ltd.
[2] When it was acquired by Kingspan Holdings (Irl) Ltd, a subsidiary of Kingspan Group Plc.

15. All the above companies form part of what in 2002/3 was the Kingspan Environmental Containers Division, now called the Kingspan Environmental and Renewables ("E & R") Division, one of the six operating divisions of the Kingspan Group. That division designs, manufactures and markets a large range of containers for oil, waste water, rainwater, oil separation and hot water. All four claimants were at material times manufacturers and suppliers of static oil tanks.

16. Unless it is necessary to distinguish between one claimant and another, or between a claimant and PDC, I shall refer to them generically as "Kingspan".

17. The E & R Division sells primarily on a wholesale basis, with the UK and Ireland as its primary market, although products are sold and distributed in France, Spain, Germany, Denmark, Poland, Czechoslovakia, Norway, Sweden and the United States.

18. So far as oil tanks are concerned the purchasers fall into two groups:

    a) wholesale distributors such as the Wolseley Group, Travis Perkins, Grafton Group and BSS Group. These in turn sell on to retailers such as plumbers and installers and sometimes to end users (thus the Wolseley Group has branches which sometimes sell on that way);

    b) large specialist installers who take full lorry load deliveries of products, such as Maskells, Tank Installation Specialists and The Oil Tank Co Ltd. They will then sell directly to the end user and will install the tanks at the user's premises.

19. The E & R Division endeavours to persuade architects, engineers, Housing Associations and other organisations, such as the National Trust, to specify their tanks for use in construction. It often tendered for tanks for the Northern Ireland Housing Executive (NIHE). If its tender was successful the tanks would be supplied by a merchant who would earn a margin from Kingspan.

20. The companies in the E & R Division would almost never enter into a direct commercial relationship with the end user or customer.

Polyethylene (PE)[3]

21. Polymerisation is effected by a process of reacting (by the use of a catalyst) monomer molecules together in a chemical reaction to form long polymer chains. In the polymerisation of ethylene ($H_2C = CH_2$) the double bonds (represented by the "=") that link the two carbon atoms in the compound are broken into a single bond to form a reactive monomer with radicals. The monomers then join to form a polymer chain of polyethylene with the general structure $[CH_2\text{-}CH_2]n$ where n is the number of repeating units which may be several thousand. The process is illustrated by the following diagram:

[3] Often referred to as polythene – the original trade name used by ICI who first produced it commercially in the 1930s in England.

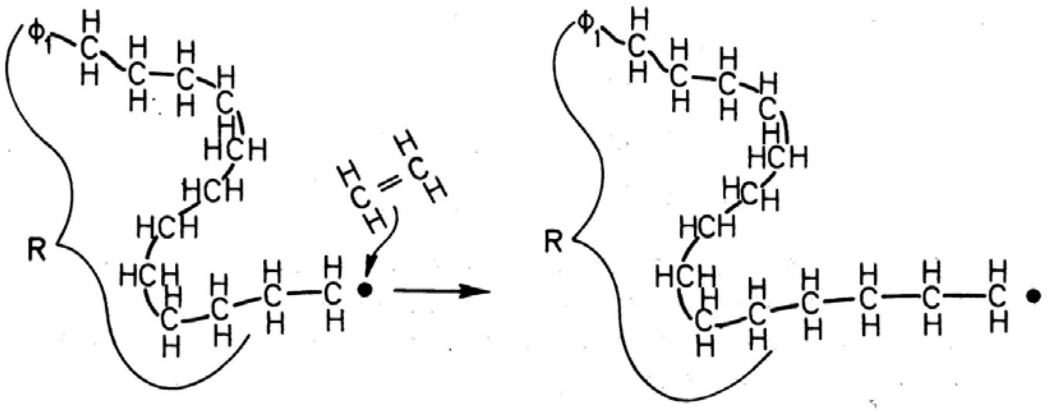


Figure 1 *Polymerization of ethylene (C_2H_4) to polyethylene. During polymerization the double bonds of ethylene are broken and the monomers are bonded together and a polymer is produced (synthesized).*

22. A polymer is, thus, a large molecule composed of repeating structural units typically connected by covalent chemical bonds (i.e. bonds formed as a result of the sharing of two electrons by two atoms). Co – monomers are often added in the process to produce a polymer with different properties (such as a reduction in density, for which butane, hexane and octane are typically used).

23. With polythenes some of the polymer chains are arranged in a very regular pattern. These are described as being in a crystalline form and are referred to as crystallites. These ordered regions are separated by amorphous material. The ratio between the ordered and the amorphous regions in a polymeric material is commonly referred to as its crystallinity, which is expressed as a percentage of the whole structure represented by the ordered material. The crystalline phase has higher rigidity and greater resistance to applied load whilst the amorphous phase is generally more flexible.

24. Polymers are often distinguished by their density as low, medium or high density polyethylenes (L/M/HDPE). Low Density PE has molecular chains with more side branches than high and medium density PEs.

25. There are currently three types of catalyst in commercial use:

    a) the Phillips catalyst based on chromium oxide;

    b) the Ziegler-Natta (ZN) catalysts[4], which are based on titanium compounds and are multiple site catalysts (the site being the place on the catalyst surface where polymerisation takes place);

    c) the metallocene catalysts which are based on titanium, zirconium or hafnium and are single site catalysts. Borecene is based on zirconium.

26. ZN catalysts were developed in the 1950s. They allowed commercial production of polypropylene as well of high density polyethylene ("HDPE") and linear low density polyethylene ("LLDPE"). Metallocene is a generic type of catalyst system for the production of polymers, first patented in the 1980s and used in industry since the

[4] Named after their inventors – Karl Ziegler and Guido Natta.

1990s. These catalysts make it possible to produce polyethylenes with a narrow molecular weight distribution: see para 29 below.

27. Borecene is a Medium Density Polyethylene ("MDPE") made with a metallocene catalyst and a hexene co-monomer. Until they began to purchase Borecene from Borealis in 2002 Kingspan had used an MDPE produced by a Ziegler-Natta catalyst. These were manufactured by a number of companies including Dow, DuPont, Polinter, Samsung, and Borealis.

Average molecular weight

28. A polymer is made up of molecular chains of varying lengths. It is unlike simpler compounds, which may be composed of identical molecules having the same structure and molecular weight. Because of the variation of the length and weight of molecule chains in polymers, polymer molecular weights are usually given as averages. Three types of averages habitually used are:

Mn – the number average molecular weight;

Mw – the weight average molecular weight;

Mz – the z average molecular weight.

Mn is the total weight divided by the total number of chains i.e. the average weight per chain. **Mw** is the total of the squares of the weights of the chains (**ΣnM^2**) divided by the total weight of the chains (**ΣnM**). It thus accentuates the significance of the longer chains because of the squaring effect and is always greater than **Mn**. **Mz** is **$\Sigma nM^3 / \Sigma nM^2$**. **Mz** is even more biased towards the higher chains because of the cubing effect of the numerator.

Molecular Weight Distribution MWD

29. The chemical structure of a polymer will differ according to the catalyst by which it has been produced. Different catalysts cause the monomers to join together in different ways. Different polymers will have different sets of molecular chain lengths and, therefore different weight average molecular weights and molecular weight distribution (MWD). MWD is a measure of the spread of the distribution of molecular weights. It is given by the ratio of **Mw** to **Mn. MWD** = **Mw** / **Mn.** If all the chains had identical weights the MWD would be 1. Typical MWD values for PE are 2 – 2.6 for narrow distribution and 2.6 – 5 for a broad distribution.

30. The table below derived from the witness statement of Ms Anne Marie Fatnes, who was the principal development engineer of Borealis Norway, shows typical values for Borecene and Borealis' ME 8154/5, a ZN which was sold as a tank grade:

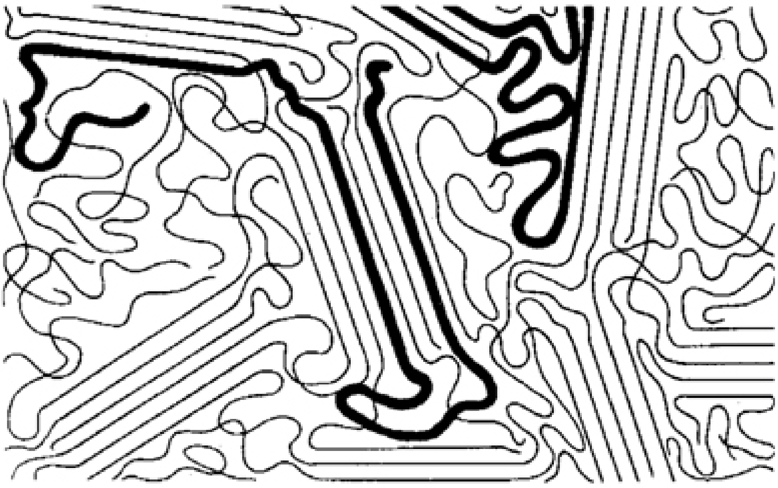
Property	Units	ME8154/5 (non-Borecene)	RM8402/3 (Borecene)	RM7402/3 (Borecene)
Density	g cm^{-3}	0.940	0.940	0.940
Melt Flow Rate(MFR)	dg min^{-1}	3.5	6	4
Mn	Kg/Mole	23,000	35,000	38,000

Mw		105,000	80,000	100,000
MWD		4.5	2.3	2.6

A higher **Mn** is an indicator of higher impact strength.

31. Polymers produced with metallocene catalysts often have a lower weight average molecular weight – **Mw** - and a narrower MWD reflecting a lower quantity of the longer and heavier chains (the high molecular weight fractions) compared with those produced with Ziegler-Natta catalysts. These longer chains, called tie molecules tie different regions of the polymer together (see para 32 below). The shear force required to produce disentanglement causing the chains to realign in the direction of the shear stress would be greater for a material with higher MW and broader MWD. Conversely, a polymer with a lower MW and narrower MWD would require less shear stress to cause disentanglement and will experience a smaller drop in viscosity in the course of disentanglement.

32. The following diagram shows (in bold) the so called tie molecules, which are links between the inter-crystalline domains of the semi-crystalline polymer. The crystalline domains are the ordered regions where the chains are in a regular pattern, as opposed to the amorphous regions where the chains are arranged like spaghetti. The ordered crystalline regions are conventionally referred to as spherulites because in most cases the crystals have a broadly spherical shape.



33. None of Kingspan's experts has measured the number of tie molecules in Borecene or been able to compare that number with a number derived from ZN material.

Melt flow index

34. Polymers are often characterised by their melt flow index (**MFI**). This is defined as the mass of the polymer, in grams, flowing in ten minutes through a die 2.1 mm in diameter and length with an applied load of 2.16 Kg at 190° C. MFI (usually specified in whole or half integers) is inversely proportional to the viscosity of the melted polymer – the higher the MFI, the lower the viscosity (resistance to flow). Borecene RM 8402 has an MFR of 6; Borecene RM 7402 has an MFR of 4. ZNs have MFRs ranging from 1.9 to 3.8.

35. A lower viscosity is likely to be regarded as advantageous by rotomoulders. The material will flow more easily round the mould; shorter moulding cycles are possible as the material melts more quickly and forms parts faster; and faster consolidation allows lower peak internal temperatures.

36. Higher MFI polyethylenes also have a lower **Mw** - weight average molecular weight. Thus MFI is an indirect measure of such molecular weight.

37. Although the term Melt Flow Index is used, the expression Melt Flow Rate (MFR) is more common.

38. It is important to note that the melt flow index test is carried out at an elevated level of shear, greater than the actual shear levels used in rotomoulding which are very low (hence the habitual reference to polythene's viscosity at zero shear). Materials whose MFI is similar (e.g. RM 7402 at 4 and Dow NG 2432 at 3.8) will have significantly different viscosity values at $0.1s^{-1}$ viz 2125 Pa.S for the former and 2792 Pa.S for the latter.

39. The conventional wisdom, prior to the introduction of Borecene, was that polythene resins with a greater MFI had higher flow properties but lesser impact strength and ESCR. Borecene, however, turned out to have improved mechanical properties: see Tables 2 & 3 and Figure 22 in the first report of Dr Nugent (Nugent 1): paras 114,126-7.

40. Metallocene catalysed PE resins like Borecene contain more highly ordered molecules (and lower amounts of amorphous material) and therefore have, as was a known feature, higher intrinsic crystallinity. Higher crystallinity imparts increased strength and stiffness compared with ZN polymers. Borecene resins are, thus, generally stiffer and stronger. Strong materials, if they fail, have a greater tendency to do so in a brittle manner but this is not always so.

41. The crystallinity of a product is affected by the conditions in which it is processed. If a tank is cooled more slowly in the course of processing, the spherulites will have more time to grow before solidification causes crystal growth to cease.

Rotomoulding

42. Kingspan manufactures its tanks by a process of rotomoulding. I described this process in my judgment in *Balmoral* in the following terms.

> *"4 Rotational moulding works in this way. A quantity of polyethylene in powdered form (the charge) is placed into one of the two halves of a steel mould, which are then clamped together. The mould, which is mounted on the arm of a machine, is introduced into an oven and continuously rotated on two axes at a low speed (typically 4- 8 revs/min), so that all parts of the interior surface of the mould pass through the pool. The charge becomes tacky and then melts in the heat (of up to around 300° C), forming a molten pool. As the powder becomes tacky it starts to stick to the mould. More powder sticks to particles that have become tacky before. As a result a layer of viscous, largely immobile, liquid forms over the entirety of the mould. The wall thickness distribution of the melt is largely determined at this stage. The product has,*

however, to remain in the oven in order to eliminate the bubbles (trapped pockets of gas) in the melt. After about 20 minutes the mould is removed from the oven and cooled. At this stage crystallization of the melt will occur. The crystallizing melt will shrink away from the mould, the rate of crystallization being dependent, in part, on the rate of cooling. When the polyethylene is sufficiently cool, the tank, as it has now become, is removed from the mould. A very high proportion of rotomoulding production is of tanks of one form or another.

Pigmentation

6 Natural polyethylene is white or yellow in colour. A very large percentage, of the oil tanks in the British Isles are "oil tank green". The standard pigment used in almost all cases, including by Balmoral, is a green phthalocyanine based pigment. There are several different brands of such pigment. The addition of a pigment has a deleterious effect on the properties of the natural product[5]. Further, pigment particles affect the way in which the polymer crystallizes as it cools and hence the crystalline structure. Some pigments, of which phthalocyanine green is one, are nucleating agents i.e. they encourage early initiation of the process of crystallisation.

7 Polymer can be mixed with a pigment in a number of different ways. The two can be **dry-blended***. In this process polyethylene in powder form is mixed with the pigment either in a blender before being added to the mould or in the mould itself. An alternative process is* **grind blending** *whereby polymer pellets are mixed with pigment and the mixture is ground into a powder. Another option is to use a* **masterbatch***. A masterbatch is created by taking a high concentration of pigment and grind blending or compounding it with a base polymer. The resulting masterbatch is then mixed either in a blender or in the mould with virgin polymer. A further process is* **compounding***. In this case polyethylene powder[6] is mixed with a pigment under heat in an extruder. The resulting pellet is then ground to powder. The blending process is sometimes carried out by the product manufacturer and sometimes by a third party.*

8 In broad terms the evenness of the spread and distribution of the pigment and the homogeneity of the resulting structure are increased, according to which option on a scale from dry blending to compounding is selected[7]. So is the expense. Dry blending involves no grinding. Grind blending a masterbatch involves grinding only a fraction of the material which will form the charge. Compounding is the most expensive of all because it

[5] It interferes with the process of powder particles sticking to each other in the moulding process and provides pathways for stress to follow.
[6] Dr Nugent explained that in the compounding process the pigment is commonly in the form of a masterbatch in which there may be equal or other proportions of pigment and polymer constituting between them a very small percentage (say 2 %) of the whole.
[7] When colourant is added by dry blending the pigment only partially coats the powder particles and is deposited at the boundaries between particles. This creates a network of potential weaknesses. It can form agglomerates which are not broken up during moulding and are significant weaknesses and possible starting points for failure.

involves an additional process[8]*. But it provides the best method of mixing and dispersion of the pigment in the product, and the least reduction in the properties of the base resin".*

43. Borealis supplied Borecene in pellet and powdered form. The Borecenes whose quality and characteristics are in issue in this case are RM 8402, with an MFR of 6, and RM 7402, with an MFR of 4. RM 8402 and RM 7402 are the pellet form. RM 8403 and 7403 are the powdered versions. Borealis supplies Ziegler Natta and Borecene of different MFIs and types with different numbers (the numbers of the pellet and powder forms being sequential, with the pellet number being the even, and the powder, the odd number). In many cases the product has been renumbered during the period with which this action is concerned. Thus RM 8402 started off life as ME 8160. **Appendix 1** to this judgment, which is not an agreed document, sets out the details of the numbering according to the Claimants.

Weathering
A general description of the process

44. All polymers, including ZN polymers, degrade over time when exposed to ultra violet light or heat (amongst other things). The exposure of an organic material such as polyethylene to heat or light in the presence of atmospheric oxygen causes the formation of free radicals which initiate and sustain the process of oxidation (light induced oxidation being faster because of the higher energy of UV light versus heat). This chemical process, unless arrested, produces changes in the polymer structure which can produce, over time, discolouration, deterioration of mechanical properties (tensile, flexural or impact strength) and the formation of visible defects such as cracks. The fact that a tank is heavily oxidised does not necessarily mean that it will fail. Nor does the fact that a crack develops necessarily mean that it will propagate through the material. Stress concentration, which may result from thin walls, thin/thickness transition (particularly at abrupt changes in section), sharp radii or pigment particles, accentuates the formation and propagation of cracks.

A more technical one

45. Degradation initiates at the weakest chemical bond. As a number of references in the technical literature record, it starts and progresses in the amorphous phase. In polyethylenes the C-H bond will, if a sufficient energy threshold is reached, undergo cleavage. UV and heat in solar light provide energy and that energy may be supplemented by stresses arising at areas of stress concentration. Once bond cleavage has occurred a sequence of reactions causes a fragmentation of the polymer chains (known as chain scission) into shorter oxidised compounds with a worsening of the polymer's mechanical properties. Scission of the tie molecules makes separation of the crystalline lamellae easier. Fragmentation results in the polymer becoming embrittled. This leads to a reduction of the impact resistance and elongation properties of the plastic. The damaged sites may also establish a new chemical bond between themselves and create a new network of polymer chains, a phenomenon known as cross linking. Research suggests that Polymers in general experience significantly more chain scission than cross linking – something like 8 to 10 times.

[8] It also requires a higher level of pigment due to the wider dispersion of pigment within the cross section of the material.

Antioxidants and light stabilisers

46. The oxidation process in polymers is inhibited by the use of additives.

47. *Antioxidants* are additives which are used to prevent the oxidation of polyethylene and other polymers as a result of exposure to heat (generated in the rotomoulding process) or oxygen. The additives react with the chemical intermediates in the process of oxidation (i.e. free radicals and peroxides) and convert them into less harmful products. Antioxidants divide into primary and secondary antioxidants. *Primary antioxidants* decompose free radicals*; secondary antioxidants* reduce peroxides. Combinations of the two are widely used in the stabilisation of polyethylene and generally provide better performance than either type alone. Antioxidants are, however, chemically unstable when exposed to ultra violet light. Other products must therefore be used to prevent the oxidative degradation of polymers resulting from exposure to light and oxygen.

48. These products are referred to as *light stabilisers*. The most common type of light stabilisers are *ultraviolet absorbers* and *hindered amine light stabilisers* (HALS). The former absorb harmful ultra violet light and convert it into harmless vibrational energy. The latter act as radical scavengers, prevent their reaction with oxygen and thereby control oxidative degradation.

49. HALS were developed in Japan by Sankyo in the 1970s and were subsequently produced and distributed worldwide by manufacturers such as Ciba-Geigy and American Cyanamid. HALS are usually categorised as low- or high-molecular weight types. The former are rarely used in polyethylene. High molecular HALS are widely used and supplied by companies such as CIBA and Cytec. They include brands known as Tinuvin 622, Chimassorb 944, Tinuvin 783 and Cyasorb UV-3346.

50. Tinuvin 622 was in widespread use in the 1980s for rotomoulding PE grades. It provided much better performance as a stabilisation system than one based on UV absorbers alone. Further improvements took place and new HALS were promoted for applications requiring longer term weathering resistance than could be achieved with Tinuvin 622. At some stage Ciba-Geigy introduced Tinuvin 783. This was a blended product consisting of 50% Tinuvin 622 and 50% Chimassorb 944, which was intended to provide a UV stabilisation performance comparable to Chimassorb 944 with less of the discolouring that the latter product had displayed. A CIBA brochure included graphs which showed Tinuvin 783 performing better than both of its constituent parts used separately.

51. The Borecene grades supplied to Kingspan by Borealis from the end of 2001 onwards were stabilised with Tinuvin 783 in combination with 1,800 ppm of the antioxidant Irganox B 215 which is a 1:2 mixture of the primary antioxidant Irganox 1010 and the secondary antioxidant Irgafos 168. No criticism is made of the antioxidant package. Borecene RM 8402 as supplied to Kingspan contained a target concentration of 1,300 ppm of Tinuvin 783 and RM 7402 had one of 1,500 ppm.

Pigments

52. Various pigments are used as colouring agents in plastics. They have different effects on the weather resistance characteristics of the final part. Generally speaking

pigments provide some protection to the polyethylene substrate by blocking the permeation of harmful ultraviolet light. Carbon black pigment, which blocks light across the whole 300-3,000 nm spectrum, is well known to have a beneficial effect in this respect. But some pigments have a negative effect on the weathering performance of polymers. Thus, some yellow and red organic pigments are unstable to ultra violet light and may actually accelerate degradation during weathering. Some phthalocyanine green pigments contain copper ions which are, to use Mr Halvorsen of Borealis' phrase, "poisonous" to polyethylene. The effect of any given pigment (i) differs not merely from colour to colour but also from particular pigment to particular pigment; (ii) may be either positive or negative; (iii) and is dependent on the concentration of the pigment and the type and concentration of the light stabiliser (s) employed.

53. Oil tanks are often made with a "tank green" colourant. The pigment used by Kingspan was such a colourant whose major component is phthalocyanine green. There are, however, many different pigments which contain phthalocyanine green.

Standards

54. Over the period with which this case is concerned various standards for weather resistance have either been in force or in the course of preparation.

OFTEC

55. The ***Oil Firing Technical Association for the Petroleum Industry*** (OFTEC) is a voluntary trade association consisting of tank manufacturers, installers, and material suppliers. The claimants were all members of OFTEC. OFTEC prescribed a standard: *OFTEC Oil Firing Equipment Standard OFS T 100:1999 Polyethylene Oil Storage Tanks and Bunds for Distillate Fuels*. That standard was published in April 1999 (replacing an earlier one in 1994) and known as OFS T 100 ("the OFTEC Standard") - for the manufacture of domestic oil tanks.

56. One of the reasons why OFTEC produced a standard of its own was because of the delay that took place in the production and coming into force of a European standard. It was introduced in order to ensure that UK tank manufacturers produced tanks in accordance with the draft European standard which was due to come into force, to which I refer below.

CEN

57. The ***Comité Européen de Normalisation*** (CEN) is a European Committee for Standardisation made up of representatives of national standard making organisations. It is charged with the responsibility of producing harmonised European standards. At the times with which this action was concerned there was a provisional European standard – prEN13341 on which the OFS T 100 standard was modelled. The working group responsible for the introduction of this standard was CEN Committee TC 266 WG4 ("the CEN Committee"). The standard was not formalised until 2005.

58. Both the prEN13341 and the OFS T 100 standards addressed the criterion of resistance to UV radiation. Prior to September 2000 prEN13341 provided:

"Weather Resistance
For outside installations, after exposure to total irradiance of 22GJ/m2 (900 kilolangleys), equivalent to 10 years exposure in a Northern European climate, the elongation at break shall be greater than 50% of the initial value"

59. The OFTEC Standard was similar. It provided as follows:

"4.1.6 *Weather Resistance*
When determined in accordance with sections 5.1.5 and 5.1.3 the elongation at break after exposure to a total irradiance of 22GJ/m2 (900 Kilolangleys) shall be greater than 50% of the initial elongation to break.

60. These terms require explanation. Irradiance is the radiant flux hitting a given surface area. Irradiance measured by relation to an interval of time is referred to as radiant exposure. The SI[9] measure of radiant exposure is J/m^2 – joules per square metre. GJ/m^2 (Gigajoules per square metre) means 10^9 J/m^2 i.e. 1 billion joules per square metre. A Langley is also a measure of irradiance, which is used in the US and other countries which do not use SI units. 1 Langley = 41,840 J/m^2. A kilolangley (Kly) is 1,000 langleys. 1 GJ m^2 = 24 Kly.

Irradiance values

61. The amount of irradiance to which a tank will be exposed depends on where it is in the world and whether and to what extent it is protected from the sun. The amount of irradiance in any given place in any given year will depend on the weather pattern and will differ from year to year. Typical solar irradiance in the British Isles is of the order of 80kly per year[10]. Tanks in the UK and NI were often, but not invariably, sold with 10 year guarantees. 10 years of solar irradiance will, therefore, equal approximately 800kly or 33.5 Gj/m^2 [11].

Elongation at break ("EaB")

62. The elongation at break test, to which the two standards refer, is a test of tensile strength. A specimen of material is taken, which may be in one of two forms. The first of these is a piece of rotomoulded product. A box or cube is rotomoulded. A piece is then cut from the side in the shape of a dog bone. The second is a compression moulded plate. This involves taking a sample from a rotomoulded product, such as the side of an oil tank, melting it and then compressing it down so that it becomes a thinner plaque. It is then made into a dog bone and tested. This form of specimen allows the testing of the thicker parts of rotomoulded products which might otherwise be too thick to be sampled.

The specimen

63. The dog bone specimen is put under stress by being stretched in a special machine until it breaks. The extent to which it becomes elongated before breaking and the percentage by which the material stretches compared to its starting length are

---

[9] The International System of Units.
[10] Different global irradiance maps such as the one used by Exxon and that used by Ciba give different figures: 70 Kly in the former and c 80-100kLy in the latter.
[11] This is a rounded figure, as is the case with a number of other conversions from Klys to GJ/m^2.

recorded. These are the reference figures. The elongation before break may be substantial – e.g. by 10 times or 1,000%. Unexposed Borecene had very substantial EaB figures. The more a material is able to be elongated without breaking the lower its brittleness and the higher its ductility.

Testing *Real time*

64. The best way to test weatherability i.e. resistance to UV would be to expose samples of the product in the area where it is to be used and to see what happens over the contemplated period of its use. But products made from polyethylene are often intended to be used for many years. Tests in real time are done; but, for practical commercial reasons, especially when a new product is involved, some form of accelerated weathering test is used.

Testing *Accelerated*

65. Accelerated testing is done in a Weather-O-Meter ("WOM"), a machine which simulates natural weathering especially by light. The specimen is placed in the WOM for what may be several thousand hours. After a specified period in the WOM, e.g. 1,000 hours, the sample is put in the stretching machine and its elongation at break ("EaB") measured. The elongation at break is expressed as a percentage of the elongation at break of the original unexposed specimen. The testing continues with other samples exposed to increasing hours in the WOM until a sample's EaB decreases to 50% of the reference value, or less, at which point it is deemed to fail the test.

66. Thus if the reference specimen was elongated by 700% when it broke originally there will be a failure if it is only elongated by 350% when it breaks (at, say, 1,000 hours) because that is 50% of the original figure.

What does EaB testing tell you?

67. The EaB test will not tell you when the material will fail. A specimen which breaks after, say, 3,000 hours will have been deliberately stretched in a manner which the polymer would not endure in service. The fact that a given polyethylene will, in those conditions, have been reduced to 50% of its original value after x hours does not mean that a tank made from the same material (to which no stretching has been applied) will fail in the field after the same interval.

68. That would be so even if the conditions in the WOM exactly replicated the conditions applicable to any given tank in service. But they do not. 80 Klys of irradiance from exposure in the WOM does not have the same effect as an overall irradiance of 80 Klys over, say, a year in service in the UK. For one thing, the exposure in the WOM is constant; whereas 80 Klys of exposure over the course of a year will be made up of extremely varied degrees of irradiance from moment to moment. And the irradiance will be at a higher rate[12]. In those circumstances things can happen to the material which would not happen in normal circumstances.

[12] Dr Botkin gave the example of being tanned in a tanning studio where the overall exposure may be the same as x hours exposure in the UK but in a much shorter period and at a higher rate.

69. There are several other reasons why there can be no equivalence. ISO 4892-1 (1999), a standard governing accelerated UV exposure, states that:

> "*even though it is very tempting, calculation of an "acceleration factor" relating "x" hours or megajoules of radiant exposure in an accelerated laboratory test to "y" months or years of actual exposure is not recommended*"

and gives, in para 4.1.4 eight factors that may decrease the degree of correlation between laboratory tests and exterior exposures. The majority of those (e.g. "*light intensities higher than those experienced in actual use conditions*") suggest that the laboratory tests will *exaggerate* the effect of the actual irradiance to which a tank may be subject. As Professor Malatesta records, light in accelerated tests is not like sunlight, and temperatures are higher than in a natural environment, and these may lead to chemical reactions which would not occur under daylight exposure.

70. There are other relevant features of the test. It mainly measures the extent to which the polymer breaks down at the surface as it degrades. This is relevant for present purposes because the tanks are said to have failed because of degradation which began on the surface as a result of UV. But the test is very sensitive to defects in the sample which may cause the sample to fail earlier for reasons other than UV degradation e.g. because of bubbles or other deformities as a result of which the sample will be stretched to break more easily than it would otherwise. FTIR testing (see para 759) may be a better method of determining whether there is UV degradation. The standard deviation on the tests is very high. Further, Borecene, as Borealis regularly pointed out, is at a disadvantage compared with other material when the EaB test is used. Its elongation to break before exposure is often much more than that of other materials; it reduces more markedly upon exposure; but, after any given exposure, the EaB which represents 50% of the original EaB figure for Borecene may still be greater than, or at least comparable to, the EaB for other materials. I call this "the EaB test disadvantage point".

71. Not surprisingly, therefore, the experts are agreed that there is no demonstrated correlation between an accelerated ageing test in a WOM and a tank's service life[13]. ISO 4892-1 recommends that results from WOM tests are best used to compare *relative* performance. Dr Botkin, Kingspan's expert, agreed that, when a sample has reached 50% of its initial EaB, it is likely to have a significant proportion of its mechanical properties intact. Mr Svein Jamtvedt, a senior polymer scientist of Borealis, whose evidence I found convincing, regarded it as a very conservative estimate of when a product was likely to fail in service.

72. When, therefore, in the rest of this judgment, exposure in the WOM is converted into years of outdoor exposure, the conversion is not to be treated as anything like exact.

Practical problems with EaB tests

[13] As is illustrated by the TA12492 CIBA project where 12 samples with a variety of base stabilisation packages were tested in a WOM and 12 samples with the same packages were subject to outdoor weathering in Florida. After practically identical exposure (600 or 590 Kly) only 4 out of 12 samples exposed in the WOM had experienced less than 50% reduction in impact strength. So 8 had failed. Only 2 of the samples exposed to outdoor weathering were close to failure.

73. In 2005 Kingspan caused RAPRA[14] to carry out a series of accelerated EaB weathering tests on four ZN grade materials (Dow, Matrix and Exxon and Borealis' RG 7402) to determine whether they complied with the requirements of prEN 13341, which was then in force. 1 mm samples compression moulded from rotomoulded tanks (as the standard then required) failed in the case of Dow after only 3,000 hours and looked likely to fail by 10,000 hours in the case of Matrix and Exxon. Since the tests were on materials which Kingspan regarded as reliable, the results took those concerned aback. The assumption was that it was the tests which were defective, not the materials.

74. In the result a proposal, which Dr McDaid supported, was made by RAPRA and Impact Laboratories, the two CEN UK accredited test houses, to change to a 4 mm sample on the basis that a 1 mm sample was "*flawed"*, being unrepresentative in terms of thickness (the tanks as made are thicker and thickness improves UV resistance) and molecular morphology. Subsequently a 3.5 mm sample was proposed and eventually EN 13341 was changed to require 3 mm samples. Dr McDaid agreed that, given the flawed nature of the test, the fact that green pigmented Borecene samples had failed the prEN 13341 standard in October 2002 was *"meaningless*".

75. In 2007 Kingspan carried out further tests through RAPRA and Impact Laboratories on 3 mm and 4.5 mm samples. The RAPRA tests showed that out of 5 materials, including Dow NG 2432, only 2 (Borealis' RG 7402, which was a ZN, and Total M 4041, a metallocene material) had not failed by 8,888 hours. Both samples failed the prEN test of $34GJ/m^2$. The Dow 3 mm sample would probably have failed the 22 GJ/m^2 test of the OFTEC Standard[15]. By contrast in the Impact tests all the materials passed after 10,700 hours.

76. Tests by Impact in 2006 on 1 mm samples from tanks produced from the Dow material by five different manufacturers had shown significantly different results (50% of original EaB at between 3,200 and 8,800 hours); and that none of the tanks would meet the 34 GJ/m^2 requirement and two would fail after 22 GJ/m^2 of exposure. Dr Botkin, a Kingspan expert, accepted that this showed that rotomoulders can significantly affect the UV resistance of the grades of materials that they use by their rotomoulding process.

77. The matters set out in the previous paragraphs indicate (a) the variability of accelerated weathering tests; (b) the fact that tanks made of material in which one has confidence based on experience can fail them; (c) the limited correlation between the results of such tests and actual performance in service; and (d) the significant effect of processing on UV performance. Similarly both pigmentation (type and method of incorporation) and design (which affects stress) affect UV resistance/weatherability.

Are EaB tests worth anything?

78. There is a measure of disagreement between the experts as to the utility of the EaB test. Professor Williams, a Kingspan expert, thought that it "*tells you almost nothing*". Dr Botkin regarded failure as a warning that oxidative degradation had started

[14] The Rubber and Plastics Research Association.

[15] On Dr Botkin's analysis. On Professor Malatesta's analysis it would just have passed it. For the difference see paras 89 -92 below.

particularly at the surface of the part. Professor Malatesta, a Borealis expert, spoke of its limitations but accepted that comparison of the results of testing two different polymers would provide useful information. Mr Schindler, a Kingspan expert, expressed the view to Kingspan when he was acting as a supplier of PE to them, that WOM data is a "*relative measure of UV stability and should not be used to extrapolate real life conditions*".

79. Whatever its merits or demerits, it has become a de facto global standard. It seems to me that the test will give a good approximation of what is probably the minimum lifetime of the polymer but that the actual life may well be much greater.

Irradiance values

80. The reference in prEN13341 (until September 2000) and in the OFTEC standard to "*22GJ/m^2 (900 kilolangleys)*" is inaccurate – a remarkable error. 22 GJ/m^2 in fact equals only about 530 Klys – about 6.5 years at an annual solar radiance of 80kly. 900 Kly is about 37.7 GJ/m^2. This error was noted at the OFTEC committee meeting on 15 September 1999 (see para 249). In September 2000 the draft of prEN13341 was revised to change from 22 GJ/m^2 to 37.6 GJ/m^2. A copy of this version was sent by Dr McDaid to Ms Fatnes on 20 September 2000. In 2001 the draft was revised to 34 GJ/m^2. This represents about 10 years at 80 Klys per year. The OFTEC 1999 Standard continued to state the weathering test requirement to be 22 GJ/m^2 until at least November 2002.

81. I say "at least November 2002" because during the course of the trial Kingspan disclosed to Borealis, as I was told in January 2012, a version of the OFTEC Standard which did not include reference to 22 GJ/m^2 but prescribed the material requirement as being that the material should "*meet the requirements of prEN13341*". No reference was made to this version in the evidence of any witness, lay or expert, or in the extensive written or oral closing submissions (which included the contention that "*The OFTS standard of April 1999 was the standard in force over the period in which Borealis supplied the Claimants with Borecene (2001-2003*")[16]; and it was only in response to a question posed by me in the course of writing this judgment that I was referred to it at all. Borealis submit that in circumstances where no suggestion had been made until then that there was an amendment in force in November 2002 it is not clear that the November 2002 amendment was in force at that date.

82. I am left in some doubt as to whether the amendment was in fact in force in November 2002. If it was, no one concerned with this case appears to have noticed it. I note that on 12 June 2003 Dr McDaid emailed to David Bradley to say that prEN13341 should be in place within six months and said that once the dates were confirmed she would draw up a timetable concerning various stages of implementation. There was no suggestion that this standard was, in effect, already in force, via the OFTEC Standard. Nor have any minutes been produced of OFTEC meetings discussing the change or any notification of it. There is no evidence that Kingspan appreciated that there had been any change in the OFTEC standard, or when they did so, or that in 2002 they made any fresh request for a letter of conformity to the prEN13341 standard.

[16] Kingspan final submissions, Tab 14, para 2.

83. If the amendment to the OFTEC standard was in force it would add a further complication. prEN13341 does not provide for a letter of conformity in respect of tank type tests. The tank is required to satisfy the prEN13341 requirements. It is not apparent that in or by November 2002 any tank testing had been done to establish satisfaction of the prEN13341 requirements. However, the November 2002 version of the OFTEC standard does still call for a letter of conformity in the case of new or alternative material grades. There is in the papers a further version of the OFTEC standard of February 2003 with the words "Amended draft" in manuscript at the top. That does have the following provision:

> "*NOTE1 Until the implementation of EN 13341 and at OFTEC'S discretion a letter of conformity from the Raw Material Manufacturer can be accepted as a means of compliance with the requirements of Table 1 of Pr EN 13341:2004"*.

84. In order to reach 34 GJ/m^2 it would be necessary to have somewhere in the region of over 13,500 - 15,300 hours in a 0.35 W/m^2 WOM and about 10,000 hours in a 0.51 W/m^2 WOM: for the distinction see paras 85- 92 below.

Measuring irradiance

85. The earth receives radiation from the sun in the form of UV radiation (wavelengths 290 - 400 nm), visible light (wavelengths 400 - 800 nm) and infrared radiation (wavelengths over 800 nm). WOMs incorporate xenon arc lamps and glass filters. With the proper lamp and filter combination, the relative level of irradiance as a function of wavelength is comparable to that of natural sunlight at wavelengths in the UV region of the spectrum (i.e. less than 400 nm).

86. Accelerated weathering using weatherometers is subject to two different industry standards: (1) ISO – 4892 *Plastics Methods of exposure to laboratory light sources* and (2) ASTM – G155 *Standard Practice for Operating Xenon Light Arc Apparatus for Exposure of Non-Metallic Materials (Florida Weather).*

87. The irradiance level of a WOM is measured at a standard wavelength (usually 340nm) and also over a range of wavelengths (usually 300 - 400 nm). Under **ISO 4892-2** the specified radiance level is **0.51 W/m^2** at 340nm, which corresponds to 60 W/m^2 over the 300-400nm range. This was the level used in the Borealis WOM and is often used in Europe. Under the OFTEC Standard the specified radiance level is **0.35 W/m^2** at 340 nm, which corresponds to 41 W/m^2 over the 300-400nm range. The OFTEC Standard required testing to be carried out at this irradiance level, which was also the level used by (i) Ciba Speciality Chemicals, (ii) Cytec Industries and (iii) in North America where weatherometers are operated in accordance with ASTM – G155 (formerly G 26) which specifies the lesser irradiance. The difference in levels means that the effect of exposure for 1,000 hours differs according to which type of WOM has been used.

UV- X

88. There is a further system of categorising resistance to UV light, namely the UV-X system. This is a North American system (first devised by Exxon Mobil in the USA). The number in the UV-X rating refers to the number of hours (in thousands) in which the product can last in a WOM operating to US standard ASTM D 2565 -99 before its

EaB reduces to 50% of its original value. This US standard has a radiance level of **0.35 W/m2** at 340 nm. Thus UV-8 corresponds to 8,000 hours in such a WOM. UV8 is equivalent to irradiation of about 20 GJ/m² or approximately 6 years outside in UK and Eire.

89. The OFTEC and CEN standards committees required performance to be measured by reference to exposure to total irradiance measured in GJ/m^2. It is possible to convert irradiance in the WOM to an estimated solar irradiance. In this respect the calculations of Kingspan's expert (Dr Botkin) are done on the basis that irradiance in the 300 – 400 nm range constitutes 6.8% of the global spectral irradiance using the **300-2,450** nm range of wavelengths, as specified in Table 1 of ISO 4892-1. Accordingly an irradiance of 60 W/m^2 over the 300 - 400 nm range corresponds to a global solar irradiance of 880 W/m^2 (60 divided by 6.8%). In order to determine the radiant energy represented by a given exposure in a WOM the global solar irradiance is multiplied by the exposure time in seconds (1 hour being 3,600 seconds).

90. For example, 4,000 hours of accelerated weathering in a WOM with a specified radiance level of **0.51** W/m^2 at 340nm corresponds to a total radiant energy of 12.7 GJ/m^2 and 305 Klys calculated as follows:

$$4000 \text{ hrs} \times 3600 \text{ sec/hr} \times 880 \text{ W/m}^2 = 12.7 \times 10^9 \text{ J/m}^2 = \mathbf{12.7\ GJ/m^2} = \mathbf{305kLy}$$

91. The defendant's expert (Professor Malatesta) proceeds on the basis that global irradiance is in the somewhat wider range of **295-3,000 nm**. As a result the calculations of the parties differ somewhat.

92. The upshot of those calculations, which are agreed but do not purport to be exact, is, by way of example, as follows:

Item	**Kly**	**GJ/m²**	**Claimants Dr Botkin**	**Defendants Prof Malatesta**
WOM providing 0.51W/m2			**Hours in the WOM**	**Hours in the WOM**
10 years outside in the UK at 80 Kly per year	800	33.5	10,700	9,300
9 years	720	30.1	9,600	8,370
8 years	640	26.8	8,600	7,440
7 years	560	23.44	7,500	6,510
WOM providing 0.35 W/m2 At 340 nm				
10 years outside in the UK at 80 Kly per year	800	33.5	15,300	13,300
9 years	720	30.1	13,800	12,000
8 years	640	26.8	12,200	10,600
7 years	560	23.44	10,700	9,300

93. **Appendix 2** to this judgment contains agreed tables giving further data in respect of years 1-6 and data from years 1 – 10 on an assumption of 90 Klys per year irradiance.

Comparison between standards

94. The interrelationship between the standards and the concepts they employ is somewhat confusing. The OFTEC Standard, which was in force as a Code to which OFTEC members agreed to subscribe, specified until at least November 2002 that sections from the moulded tank should have an EaB of more than 50% of the initial EaB after exposure to *"22 GJ/m² (900 Klys)"*. It said nothing about 10 years. 900 Klys would represent 10 years of exposure in Northern Europe on a basis of 90 Klys per year. The OFTEC Standard prescribed a test in a WOM of 0.35 W/m² for 10,000 hours. This would not amount to 900 Klys although it would amount to about 22 GJ/m². So the test procedure married up with the 22 GJ/m² figure (about 6 years). Had a WOM of 0.51 W/m² been prescribed it would have been equivalent to 800-900 Klys.

95. The prEN13341 standard, which was not in force until 26 April 2005, referred (initially) to "*22 GJ/m² (900 Klys)"*. That was expressed to be "*equivalent to 10 years exposure in a Northern European climate*". The latter quoted words were included when the figure was changed to 37.6 GJ/m², but omitted when it was changed to 34 GJ/m². The standard required testing in a WOM of 0.51 W/m² on samples cut from the moulded tank. Kingspan did not sell its tanks as CEN certified.

Tensile Impact tests

96. Impact tests are often used to measure the resistance of polyethylenes to impact and may provide useful information and enable a ranking of materials. It was Dr Botkin's view that such tests are a much less sensitive means of assessing surface degradation resulting from weathering than EaB tests because, in his experience, the tensile impact strength of a polyethylene decreases much more slowly during weathering than does its elongation at break. By contrast both Mr Jamtvedt and Ms Fatnes, and Professor Marshall, regarded tensile impact tests as more reliable because of the sensitivity of EaB tests to sample selection and the high degree of variation. In addition they did not discriminate against Borecene in the manner described in para 70 above. Tensile impact testing was the testing method used by CIBA and preferred by KIWA (the Dutch certification body).

97. In one version of the test a specimen is struck by a weighted pendulum with a striker attached moving at high speed and the amount of energy per unit area expressed in J/mm² required to break the test specimen is the tensile impact strength.

98. In another version measurements are taken either of the height from which a striker has to drop, or the weight of the striker that has to be used from an unchanging height, in order for failure to occur. A load measuring instrument can be incorporated in the striker head to measure the loads and deflections at the moment when the striker is in contact with the specimen. This test is commonly carried out when the PE has been held at very low temperatures, e.g. - 40°C (to encourage embrittlement). Kingspan and their experts have not carried out any such tests. A series of tests carried out before 2002 showed that Borecene had superior impact characteristics to non Borecene resins as its increased crystallinity would lead you to expect: see the first

report of Professor Marshall (Marshall 1) para 179. This was likely to give it greater tolerance to processing variables.

The OFTEC Standard

99. The OFTEC Standard contains a number of definitions including:

> *"3.5 Raw Material*
> *A raw material is a virgin material of single density and single melt flow index*
>
> *3.6 Pigment*
> *A pigment is a coloured material which when dispersed in the raw material imparts colour and/or opacity. "*

100. Section 4 is headed "*REQUIREMENTS"*. It provides in para 4.1 for "*Material requirements"* and in para 4.2. for "*Constructional Requirements*". Section 5 is headed "*TEST METHODS*". Section 5.1. prescribes "*Material Tests"* and Section 5.2. *"Construction Tests"*.

The Material Requirements of the Standard

101. Sections 4.1.1 and 4.1.2 provide for material composition and density.

Melt Flow Rate

102. Section 4.1.3 is headed Melt Flow Rate and reads:

> "*When determined in accordance with Section 5.1.2 the melt flow rate* ***of the raw material*** *shall be less than 5g/10 min and greater than 1.5g/10 min. The melt flow index measured* ***on the moulded tank*** *shall have a maximum allowable variation of -15% and + 15% of that value measured on the raw material used.*
>
> *Where a PE grade is used that is not a conventional MDPE (e.g. a metallocene) then a Melt Flow Rate outside this tolerance may be allowed if the suitability of the grade can be proved".* [Bold added]

103. The second paragraph of section 4.1.3 was added in April 1999 with the introduction of Borecene which often has MFRs in excess of 5.

104. Section 5.1.2. provides:

> ***"5.1.2. Melt Flow Rate***
> *The melt flow rate is measured* ***on the raw materials*** *and on sections taken from any location* ***on the moulded tank*** *and of the bund and of the bund cover, in accordance with ISO 1133 Condition 4."* [Bold added (apart from heading)]

105. As can be seen sections 4.1.3.and 5.1.2 require a measurement of the MFR of both the raw material (which Borealis produces) and "the moulded tank" and any bund or bund cover. In addition sections 4.1.4 (Tensile Properties) and 4.1.5 (Resistance against

Oil) are requirements which are to be determined in accordance with sections 5.1.3.and 5.1.4 which call for test samples to be sections of "*the moulded tank*", any bund and in the case of 5.1.4 bund cover.

106. There is good reason for requiring tests on the moulded tank. In the case of Weather Resistance, for instance, the processing of the polymer, the nature, quality and quantity of the pigment and the way in which it is mixed with the polymer (dry blending, compounding, or masterbatch) may affect, beneficially or prejudicially, its weather resistance characteristics. So also may the design of the tanks and the wall thickness and wall thickness variation involved.

Weather Resistance

107. Section 4.1.6 provides, as we have seen :

"**4.1.6 *Weather Resistance***

When determined in accordance with sections 5.1.5 and 5.1.3 the elongation at break after exposure to a total irradiance of 22GJ/m^2 (900 Kilolangleys)[17] *shall be greater than 50% of the initial elongation to break."*

108. Section 5.1.5 provides

*"**5.1.5 Weather Resistance***

Samples cut from **the moulded tank***, the bund and the bund lid are exposed to UV radiation with a Xenon lamp in accordance with ISO 4892. Alternatively, test specimens can be taken from compression moulded sheets, moulded from pieces from the moulded tank, bund and bund lid.*

The condition of the weather test will be:

(a)	*Xenon*
(b)	*Black Standard Temperature 65°C*
(c)	*R.H. – 50%*
(d)	*Spray – 18/102*
(e)	*Test duration – 10,000 hours*
(f)	*Test irradiance at 340 nm –* **0.35 w/m^2** *"*

[Bold added (apart from heading)]

As can be seen from the table at para 92 above this implies something of the order of 560 Kly - 7 years assuming annual irradiance of 80 Kly. More importantly the test equates to a total irradiance of 22 GJ/m^2 when 10 years irradiance in the UK per year at 80 Kly would be of the order of 33.5 GJ/m^2.

The Constructional Requirements of the Standard.

109. Sections 4.2.1 – 4.2.10 make a number of constructional requirements under the headings; Nominal Capacity and Tolerance, Visual Inspection, Weight, Wall Thickness, Impact Requirements etc. Para 4.2.4 provides:

[17] These are not, of course, equivalent.

"***4.2.4 Wall Thickness***

For storage of Class C1 and C2 fuel to BS 2869 the minimum thickness for the tank or bund shall be 4.5mm.

A margin of 10% of the wall thickness is permitted in zones clearly defined by the manufacturer on a specification document submitted to the OFCERT Directorate, with justification that it has no effects on the physical properties of the tank."

110. This requirement was imposed in order to provide a sufficient protection against the permeation of fuel though the tank. It is not concerned with structural integrity.

111. Para 4.2.6. provides:

*"**4.2.6 Deformation Requirement for Tanks***
4.2.6.1 Tanks with a brimful capacity equal to or less than 3500 litres

When tested in accordance with **Section 5.2.6.1** *the deformations shall be as follows:*

Max increase in volume	*12.5%*
Max increase in length	*12.5%*
Max increase in width	*13.5%*

In the case of a vertical cylindrical tank only the volumetric limit shall apply"

112. Section 5.2.6.1. provides (for tanks less than 3,500 litres) the following creep test[18]:

*"**5.2.6.1** The tank shall be subjected for 42 days to a hydraulic pressure 30% greater than that which would be exerted at the lowest point of a full tank. The temperature of the test room shall be 23°C ± 2°C.*

The test shall be carried out as follows:

Locate the tank in the centre of a reference grid
Stabilise the tank in position by the addition of 300mm of water
Measure the width and length of the tank
Fill the tank with water at approximately 700 litres/hr ± 100 litres/hr
Measure the capacity to within ± 0.5%
Apply the excess pressure. Check and maintain the excess once per day during 42 days
Measure the change in length, width and volume, immediately after applying the excess once per day during the 42 days. Check daily whether the dimensions still comply with the requirements."

Type Tests

[18] "Creep" is used to describe the process of gradual disentanglement of molecules, largely in the amorphous phase, which will cause deflections to increase, slowly but continuously, with time.

113. Section 6 provides:

> *"**6.0 TYPE TEST***
>
> *A letter of conformity to* **Sections 5.1.1** *to* **5.1.5** *from the material supplier is required.*
>
> *The following lists of tests, described in* **Section 5** *of this standard, should be carried out when a tank is being type tested:*
>
> ***5.2.1*** *Nominal Capacity and Tolerance*
> ***5.2.2*** *Visual Inspection*
> ***5.2.3*** *Weight*
> ***5.2.4*** *Wall Thickness*
> ***5.2.5*** *Impact*
> ***5.2.6*** *Tank Deformation Test*
> ***5.2.7*** *Tank Pressure Test*
> ***5.2.8*** *Leak Proof Test for Tanks*
> ***5.2.9*** *Bund Deformation Test*
> ***5.2.10*** *Bund overflow Test"*

New Materials

114. Section 10 provides:

> *"**10. APPROVED MATERIAL GRADES AND NEW OR ALTERNATIVE MATERIAL GRADES***
>
> ***10.1*** *Where a manufacturer has an approved range of models in a particular grade of MDPE, the method of approval for a new or alternative grade to* **Section 4.2** *is as follows:*
>
> *1) The Test House shall identify up to three models of tank in the range for assessment in the new material, based on performance against OFS T100* **Section 4.2** *in the conventional grade.*
>
> *2) The manufacturer shall supply those models identified for full testing to OFS T100* **Section 4.2***. The samples shall be of conventional weight of the tank model under review.*
>
> *3) The results found shall be compared to the conventional material, and where the comparison is favourable, a full pass across the whole range of approved models can be given to* **Section 4.2***.*
>
> *4) Full approval is at the discretion of OFTEC and requires a Letter of Conformity for the Raw Material and an ISO approved Quality System as specified in* **7.2***.*

Interpretation of the Standard

115. The Standard by its terms requires that conforming tanks should in fact satisfy the Weather Resistance (as well as other) material tests. Section 1 of the Standard, headed "*Scope*", provides that "*This standard specifies* ***requirements*** *for static thermoplastic tanks...*" [Bold added]. The same section provides that "*The purpose of this standard is to define material used, requirements and test methods for type tests and production quality control tests*". One of those requirements is that the samples for the section 5.1.5 test should be samples from one of the moulded tanks whose type was being tested. A requirement to take samples from the moulded tank was also made in respect of the Melt Flow Rate under 5.1.2 (see para 104 above), the Tensile test under 5.1.3, and the Resistance against Oil test under 5.1.4.

The meaning of sections 6 and 10

116. The Standard thus contemplates two forms of test:

i) the Type Test under section 6; and

ii) the approval of a new or alternative grade of material under section 10.

117. Under section 6 a type of tank is under test. The second paragraph of the section requires the construction tests specified in section 5.2 to be carried out and the first requires a letter of conformity to the material tests from the material supplier. One of the requirements of the material tests (Density) calls for a test on the raw material only. Another (Melt Flow Rate) calls for tests both on the material and the moulded tank. The remaining three require tests to be carried out only on the moulded tank. Since the material supplier will not be the manufacturer of the moulded tank being tested, the question arises as to what the letter of conformity is required to say in respect of tests on a section from the moulded tank. Is it to state (i) that the material supplier expects the material to satisfy the moulded tank tests; (ii) that the supplier warrants that it will; or (iii) that the supplier has carried out the moulded tank tests on a tank of the type under test or, at any rate, some form of moulded tank; or (iv) something else?

118. The problem is particularly acute in relation to the Weather Resistance test which requires thousands of hours of radiation and where the characteristics of the moulded tank will or may fundamentally affect its weather resistance and are entirely in the hands of the manufacturer. In the ordinary course of things the material supplier may, as Borealis did, have the means of manufacturing some form of product – in Borealis' case a small production machine on which they used, mainly, a square box mould but for which they had moulds with more complex shapes. But it will not know, unless told, the pigment to be used by the manufacturer, the details of the design of the tank or the intended processing conditions and is unlikely to be able to replicate them. It cannot, therefore, testify to compliance (as opposed to an expectation of compliance) unless it has been provided (as Borealis never was) with a section of the moulded tank and has carried out the relevant tests.

Kingspan's interpretation

119. PDC interpreted the Standard as allowing Kingspan to satisfy OFTEC's requirements without conducting its own tests on the material on the basis that it was incumbent on the material supplier to establish that the products produced using the material

satisfied the UV thresholds. In the event none of the claimants carried out, nor did they procure to be carried out, any of the moulded tank tests on any tank that they had made. What they did do was to obtain letters of conformity from Borealis.

120. Borealis submits that Kingspan was in error. It is for the tank manufacturer, whose processes and pigmentation can fundamentally alter the raw material, to meet the requirements by carrying out the tests on his moulded tanks which the Standard prescribes.

The letter of conformity

121. The first Borealis letter of conformity, issued on 16 August 1999, was in the following terms:

> *"This is to inform you that the Borealis Polyethylene ME8161 as supplied to PDC, when processed according to Good manufacturing practice, is expected to meet the requirements of the OFTEC Oil Firing Equipment Standard OFS T100 (May 1994). That is/*
>
> *5. Weather resistance exceeding 22 GJ (TUVR)."*

The letter also addressed 1 Density; 2 MFR; 3 Tensile Properties; and 4 Resistance against Oil.

The genesis of letters of conformity

122. There was a reason for, and a history behind, the use of letters such as this. The Polymer Development Centre at Athlone (hereafter "Athlone" to avoid confusion with PDC), which was the OFTEC approved Test House, did not at the relevant time have the capability to carry out UV weathering tests. In early 1999 it was thought that a WOM would be available by July. In the event it was not available until after 2003. (Mr Gregg's evidence was that the test equipment had to be certified by a body called NAMAS[19] to ensure that the correct levels of radiation were delivered by the machine and that there was some problem with the equipment as a result of which Athlone concluded that they could not test in accordance with the European standard). The problem could not be solved by the use of another Test House because there was no OFTEC approved Test House capable of performing the UV weather resistance test. Kingspan, itself, did not have the ability to undertake testing according to the Standard; and was not approved for the purpose[20].

123. Reference to a letter of conformity in the OFTEC Standard first appeared in the 1999 version. Para 6 of the June 1994 version had said "*The following list of tests, described in section 5 of this standard should be carried out when a tank is being type tested*". There then followed a list of the material and constructional tests. But a practice developed of material suppliers issuing letters of conformity: see the letter of conformity given by Enichem to Plashapes (Titan) in September 1994, in which

[19] National Measurement Accreditation Service.

[20] That does not mean that the testing could not have been carried out elsewhere. As Mr Gregg accepted, it obviously could have been.

Enichem stated that *"the following parameters* ***as measured in our laboratories*** *do comply with the requirements of [the Standard]*" [Bold added], and then set out the material requirements.

124. Athlone produced a template for letters of conformity. In January 1999 Athlone faxed to Mr Gregg of PDC a letter of conformity with the name of the material redacted and "*grade name + material supplier name*" inserted which read:

> "*This is to inform you that the grade name + material supplier name, when processed according to Good Manufacturing Practice, is expected to meet the requirements of the OFTEC Oil Firing Equipment Standard OFS T100 (May 1994)*"

Against this appear in manuscript the words added by the sender "*Typical statement*". There were then set out the 5 material properties (Density, MFI, Tensile properties, Resistance against Oil, and Weather Resistance) and the criteria applicable. The last of those was:

> *"Weather Resistance exceeding 22 GJ (TUVR)*"

A typed up copy with the words "*Supplier Letterhead*" dated 12 January 1999 with the added words "*as supplied to the Kingspan Group"* after "*...material supplier name"* was also generated by Kingspan.

125. The reference to 22GJ should obviously read GJ/m^2. TUVR stands for Total Ultra Violet Resistance whereas the Standard refers to total irradiance.

Examples of letters of conformity

126. Polimeri Europa France ("Polimeri") provided a letter of conformity for Titan in February 1999 with similar introductory words to those set out above in respect of a material which was similar to DuPont 8504. This indicated in relation to the tests which referred to moulded tanks that "*The test is made on the final article ant (sic) thus we cannot give guarantee; but from our general knowledge we expect it to comply*".

127. In August 2000 Mr Peter Schindler, who was then working with Dow, gave Kingspan a certificate of conformity in respect of Dowlex NG 2432 which was in the "expected to meet the requirements" form. In it he recommended confirming the tensile and resistance to oil requirements in Kingspan's own laboratory because the tests "*were supposed to be tested on a piece of moulded tank*"; and said, in relation to the weathering requirement, that the natural material had just passed, and pigmented samples would have to be tested, which were expected to show improved resistance. His evidence was that, even with a letter of conformity, he advised rotomoulders to test the product themselves.

128. OFTEC was well aware of the practice of relying on letters of conformity as appears from an annex to the minutes of an OFTEC meeting on June 11 1998:

> *"At present there is no independent testing carried out on material properties. MA*[21] *has prepared a price list for the various tests which can be conducted at the Polymer Development centre and it will be up to the Committee to decide whether to proceed down this route or stick* ***with the current arrangement of accepting manufacturers' certification".*** [Bold added]

129. In 1998 and 1999 there was some discussion within OFTEC as to how to deal with these problems. The idea of a list of materials that had already been approved was mooted but that idea was not progressed.

THE PROPOSED AMENDMENTS TO OFS T100

130. On **18 February 1999** Mr Mark Atterbury, the technical manager of Athlone sent a memo to OFTEC Committee OFC/4, a subcommittee of plastic and steel tank manufacturers ("the Tank Committee"), with a proposed final draft of an updated version of the 1994 standard. The proposal was that section 6 should begin with the sentence: "*A letter of conformity to sections 5.1.1 to 5.1.5 from the material supplier is required until further notice from the OFTEC directorat*e". The idea was, as Mr Gregg explained, that letters of conformity were to be used until material testing could be undertaken in compliance with the OFTEC Standard and the pending EN13341 standard.

THE APRIL 1999 VERSION OF THE OFTEC STANDARD

131. The April 1999 version of the OFTEC Standard introduced the requirement for a letter of conformity in respect of the section 5.1 material tests requirements by the inclusion of the following as the opening sentence of section 6:

> *"A letter of conformity to Sections 5.1.1 to 5.1.5 from the material supplier is required"*

coupled with the enumeration in the "*following list of tests ... to be carried out*" of the constructional, but not the material, requirements.

132. It is apparent from the history leading up to the amendment and its terms that OFTEC contemplated that the type test would, so far as material requirements were concerned, be satisfied by a letter of conformity from the material supplier. Whilst the Standard did not exhibit a typical letter, OFTEC must have contemplated the continued use of the template that Athlone had earlier put forward.

133. Section 10 of the 1999 Standard was also new. It was entitled "*Approved Material Grades and New or Alternative Material Grades*". Its terms are set out in para 114 above. It deals with the situation where a tank type has already been approved by the manufacturer who wishes to make that tank from a new material. In such a case Section 10 required the section 4.2/5.2 tank construction tests to be carried out at Athlone on up to 3 models of tanks. An OFTEC certificate could then be issued once the material supplier provided the manufacturer with a Letter of Conformity in respect of the Raw Material (and the site had an ISO Approved Quality System) This was how Dr McDaid understood the system to work.

[21] Mark Atterbury

134. That begs the question as to what "*a Letter of Conformity for the Raw Material*" under 10.1.4 was supposed to relate to. Borealis draws attention to the reference to "*the Raw Material*" i.e. the virgin polymer and submits that that means that only the characteristics of the raw material specified in section 5, which do not include the weathering requirement, need be the subject of the letter. I do not regard this as correct. It seems to me that the Standard intended that, in the event of a new material, the same sort of letter of conformity should be given as under section 6 i.e. a letter of conformity to sections 5.1.1. to 5.1.5. In any event it was such a letter which Borealis gave.

135. This situation meant that, whilst the OFTEC Standard laid down requirements which could only be met if samples from the moulded tank satisfied the requisite test, OFTEC was prepared to treat compliance with those requirements as established without any test having been carried out by any Test House on the moulded tank in question, on the basis of a letter of conformity from the material supplier as to his expectations of how his material, once moulded, would perform. Any such expectations could not, as Kingspan knew, have been based on any testing on sections from the tanks as moulded by Kingspan and with the pigment used by it[22].

136. This was an unsatisfactory state of affairs in relation to tanks intended to hold inflammable liquids capable of causing great environmental damage. A material, which the Standard required to be tested on rotomoulded tanks, would, from Oftec's perspective be approved as an alternative material grade, and a tank made from that material would pass the OFTEC tank type test, even though the material and any tank made with that material had not been tested as the Standard required. This state of affairs resulted in part from the fact that testing for UV resistance is a time consuming and expensive exercise (about £ 3 per hour in 1998 for what might take over a year if the WOM was to replicate 900 Klys) which Kingspan and other tank manufacturers wished to avoid if they could. Moreover the need to carry out such testing could be a significant disincentive to any rotomoulder who contemplated changing material, and thus a problem for anyone who might seek to persuade them to do so.

137. I recognise that WOM trials carried out on natural Borecene (or any other new material) will enable some assessment to be made as to how long tanks made from it could be expected to last. The value of any such assessment depends on the nature of the tests and the results. These might well be an inadequate substitute for tests on the tanks as made by the manufacturer in question, which is what the Standard requires, particularly when the pigment and process adopted could make a very substantial difference (in either direction) to the weather resistance of the end product. If a manufacturer wants to know how well his tank will weather he needs to perform weathering tests on pieces cut from a tank made by his process, with his pigment and to his designs. That is what Dr Botkin, Kingspan's expert, would emphatically have encouraged; and he would have cautioned against selling tanks without testing of those tanks against the OFTEC Standard.

138. Dr McDaid said that she thought that a letter of conformity was as good as the Section 4 tests. But it was not. Mr Gregg, who had no real understanding of the effect of UV

[22] Mr Gregg's evidence at trial was that he assumed that Borealis had done some of the necessary tests, although at the time the question of the tests had never crossed his mind. If he had thought about it, he could have had no basis for thinking that tests had been done on sections from a Kingspan moulded tank.

light, accepted that he looked on OFTEC Standard compliance as a tick-box exercise, rather than working out what Section 4 required.

BOREALIS' KNOWLEDGE OF THE STANDARD AND THE ROLE OF THE LETTER OF CONFORMITY

139. Borealis knew of the OFTEC Standard at the beginning of its dealings with Kingspan. It was, itself, a member of OFTEC. Ms Fatnes attended meetings on its behalf from 18 February 1999 onwards (Mr Shorter had attended before). She was well aware of the OFTEC weathering requirement.

140. She also became aware – see paragraph 249 below – that the figure of 22 GJ/m^2 was an incorrect conversion of 900 Klys and should have been c. 37.5 GJ/m^2 and that to resist 900 Klys a tank would have to withstand much more than 22 GJ/m^2.

141. I am, also, satisfied that Borealis knew that, for OFTEC purposes, the letter of conformity was intended to constitute evidence of compliance with the material requirements of OFS T100, and to constitute a representation by it (but not a warranty) that the material referred to in the letter was expected to provide the specified level of weather resistance, if processed in accordance with good manufacturing practice. That that is so is apparent from the matters to which I refer in paragraphs 142-155 below.

Borealis' experience of the letter of conformity

142. On **22 December 1996**, Borealis sent to Athlone a letter of conformity for several grades, including its Borecene grade ME 8166. The letter stated that those grades, when processed according to good manufacturing practice, were expected to meet the requirements of the OFTEC Standard (then in its 1994 form).

143. On **18 February 1999** Ms Fatnes attended the Tank Committee, of which Mr Gregg was a member and whose minutes Dr McDaid saw. The agenda for the meeting indicates that proposed amendments to the OFTEC Standard were to be discussed. Mr Atterbury had provided a memorandum of that date dealing with that subject. Manuscript notations on the memorandum (probably in Ms Fatnes' hand) show that it was to be copied to three individuals at Borealis who did not attend the meeting. The proposed amendments to the OFTEC Standard were discussed and the proposed amendments were attached to the minutes.

144. The minutes record that there was discussion about the need to define the weathering standard, in relation to which Mr Atterbury and Ms Fatnes and Mr Shorter were to liaise. (Nothing appears to have come of this). Mr Gregg and Mr Atterbury raised the possibility of specifying a stabilisation system which would conform to the weathering requirement as a short route to approval. It was noted that pigment type and opacity (i.e. the concentration of the pigment) had a major bearing on weathering stability and should be taken into account.

145. Agreement was reached on allowing a higher MFR tolerance for unconventional MDPE grades (e.g. Borecene) available now or in the future. The Minutes record:

> *"The regime of OFTEC tests on the tank would prove the suitability of the material. [Mark Atterbury] advised that it was important that suppliers of new material grades have knowledge of the expected effect of contact with fuels to assure conformance with the resistance to oil requirement in particular."*

146. On **19 February 1999** Mr Shorter, now of ICO Europe, sent to Messrs Webster, Wood and Tew of Borealis a fax which referred to two very good points having come out of the meeting of which the second was:

> *"(b) "The letter of conformity, for base grades, has been accepted and will continue. This means that I can still write a letter confirming the grade specification to enable moulders to use grades while they are still under test at PDC [Athlone][23]. This is obviously based on the fact that they comply with the base resin requirements as laid down by OFTEC."*

147. On **22 February 1999** Ms Fatnes sent an internal email in which she agreed that Mr Shorter had summarised some of the highlights of the meeting and observed:

> *"**Letter of conformity still accepted during tank test period***
> ***…..***
>
> *Test procedure regarding weathering still not finalised. [MA] has the responsibility for making a proposal before the next meeting. Here I think we (Borealis) should give some input as well"* [Bold added]

148. Ms Fatnes said during part of her evidence that her understanding was that a letter of conformity would be part of the approval process but that there would be some form of testing of a moulded tank "*representing the tanks, using the correct pigment, using the correct processing conditions*". At other stages she appeared to accept that the provision of a letter instead of section 5.1 tests was probably the implication of the proposed amendments and that she had understood as much.

149. The likelihood is that, although she did not address her mind to this very clearly, at this stage (February 1999) she realised that the proposal was that OFTEC weathering and other material requirements were to continue to be met, so far as OFTEC testing was concerned, through the provision of a letter of conformity from the material supplier, pending the completion of any Athlone testing. The practice, which had begun before then, of OFTEC treating a letter of conformity as satisfying the test simply continued, in part, no doubt, because WOM testing at Athlone did not become available in July 1999 as expected, although it did at some later date. This was not an issue of any great consequence at the time because UV weatherability had not surfaced as an issue of concern.

150. Consistently with this in November 1999, after Borealis had provided a letter of conformity for Borecene, Ms Fatnes said in a Borealis sales pack that Borecene "*meets regulations (example OFTEC)*", which she could scarcely have said if she

[23] I presume what he was contemplating was that Athlone would carry out, e.g. WOM tests, and that a letter of conformity would suffice whilst they were still under way.

thought the question whether or not it did so depended on whether the tank manufacturer had carried out the material tests.

151. On **18 May 1999** Dr McDaid of PDC wrote to Bob Wood, the Rotomoulding Sales Manager of Borealis UK, saying:

> *"As discussed with Dessie 17th May 1999, please find attached a copy of Conformity Certificate as required by OFTEC*
>
> *Materials that pass the OFTEC tank tests must also comply with the material requirements in the standard T-100. Only after receiving such a letter from the material manufacturer can OFTEC give a full pass on a new tank material.*
>
> *Please supply a letter stating that ME8160/1, as supplied by Borealis conforms with each of the listed requirements."*

She attached a copy of the 12 January 1999 draft (see para 125 above). This letter shows Dr McDaid's understanding that it was a letter from the material manufacturer in relation to the material which would lead to "*a full pass"*.

152. In **September 1999** Mr Atterbury circulated a report to the Tank Committee, which met on 15 September (see para 249 below). This included the following:

> "*Several members are running into difficulties with letters of conformity for new material grades with regards to weathering requirements.*
>
> *Essentially, the weathering test can take up to 18 months to complete which is impractical in a commercial environment.*
>
> *Some material suppliers with new grades (which are still fundamentally MDPE) are insisting on carrying out the weathering test prior to advising on conformance to the OFTEC standard, which is of course the most responsible reaction. However, where members have fully approved their tank model range in the new material by having them successfully tested against the constructional tests, they are having to wait 18 months for the full letter of conformity to be produced."*

153. It is apparent from this report:

a) that Mr Atterbury, and therefore, Athlone, was treating it as an obligation of the material supplier to determine whether it could produce the requisite certificate for the purpose of section 4.1. in order that an OFTEC certificate could be obtained; and

b) that some suppliers were carrying out weathering tests for up to 18 months before being prepared to certify.

His report proposed a new approach (never in fact implemented) to the effect that when a material had been successfully tested (presumably in respect of the requirements other than weathering) and only awaited confirmation that it met the weathering requirements, the member concerned should arrange for the material supplier to carry out the full weathering test. Meanwhile the member concerned should obtain information on the pigment and additive package being used and either obtain a statement from the additive supplier that the additive package would be expected to meet the weathering requirements of the standard and/or submit all information on the pigment and additive package to the Test House which would make an independent judgement on the expected weather resistance.

154. The Tank Committee met again on **9 February 2000.** Mr Atterbury reported that the OFTEC Standard weathering tests took 18 months to complete and were very expensive. According to the minutes he said that the timescale associated with the test should be reviewed subject to appropriate letters of conformity from material suppliers. (This again appears to contemplate use of the letter of conformity pending the completion of the test). A working group was formed to consider new wording to be proposed to the OFCERT Committee.

155. An understanding of the function of the letter of conformity appears from a report of the Construction Industry Research and Information Association ("CIRIA") in 2000. CIRIA was engaged in research into the manufacture and manufacturing requirements of external oil storage tanks. Borealis (and in particular, Ms Fatnes) received literature from CIRIA, including a *Review of Above Ground Proprietary Prefabricated Bunded Oil Storage Tanks* (Paper 603/19). Appendix C of that report (internal page 121) addresses the requirements in the Standard. After listing the material requirements of section 4.1 it stated:

> "*Usually these requirements are met by a letter of conformity. This letter, from the polymer manufacturers, must guarantee that the material used in the manufacture of the oil storage tanks meets the requirements detailed in OFS T100*."

That is, in my judgement, an inaccurate characterisation of the letter of conformity which is not a guarantee: see below.

The nature of the representation in the letter of conformity

156. A representation that the material is expected to provide the relevant level of weather resistance, if processed in accordance with good manufacturing practice, begs the question whether that means the material in its natural or in its pigmented state. It cannot refer to the material's raw state (powder or pellet) because no EaB tests can be carried out on such material and the letter of conformity refers to the material being *manufactured* in accordance with good manufacturing practice.

157. The representation must, as it seems to me, refer to the material in the form in which Kingspan intended to use it i.e. pigmented with green pigment.

158. I say that for two reasons. First, the letter related to the tank as manufactured. Kingspan's tanks for outdoor oil storage were, as all concerned knew, habitually made out of green pigmented polymer, as were the tanks of many other manufacturers. Second, Ms Fatnes made clear in her evidence that in issuing the letter of conformity she was taking account of the effect of green pigment. It was also Dr McDaid's understanding that the letter of conformity applied to the green moulded material.

The meaning of 10.1.4 in the Standard

159. Section 10.1.4 provides:

> *"4 Full approval is at the discretion of OFTEC and requires a Letter of Conformity for the* **Raw Material** *and an ISO approved Quality System as specified in 7.2."* [Bold added]

160. Borealis argues that the reference to Raw Material is necessarily a reference to Raw Material as defined ("*a virgin material of a single density and single melt flow index*") such that any letter of conformity can only legitimately provide comfort in relation to the characteristics of the virgin unprocessed material. I reject this. In the context in which it appears section 10 is contemplating a letter of conformity for the virgin material which will express a view as to how that material will perform once moulded into a tank.

161. The contrary conclusion would:

a) involve giving "*letter of conformity*" in section 10 a different scope to its scope in section 6, which provides for the letter of conformity to relate to all tests in respect of material specified in sections 5.1. to 5.5;

b) mean that, although the type of letter of conformity which all concerned knew was in use, and whose continued use was contemplated, covered all the material requirements on a change of material, the need for a letter of conformity (and the letter itself) applied only to those requirements which related to the virgin material, namely density and melt flow index;

c) leave a gap, in that approval could be given under section 10 with no certificate or test in respect of the other material requirements; and

d) be inconsistent with the manner in which Borealis, OFTEC and Kingspan all proceeded.

The structure of this judgment

162. The events leading up to Kingspan's decision to purchase Borecene, the purchases of Borecene, and the effects of Kingspan using it cover a period of over 7 years. Kingspan relies on what was said to them over that period in promotional material, certificates of conformity, an email of 18 November 2001, and at a meeting on 3 December 2002, and on other occasions, as misrepresentations as to the UV stability of Borecene in respect of which they are entitled to claim. There is an issue between the parties as to:

i) the terms of their contracts;

ii) whether they are governed by English or Danish law, and

iii) whether, if Danish, the law of Denmark (which has no doctrine of misrepresentation) is the law which should determine whether any claim can be made in respect of pre-contractual statements.

There is also dispute as to:

(a) what representations, if any, were made;

(b) which representations have been pleaded and can be advanced in these proceedings;

(c) whether any representations were in fact relied on;

(d) whether any were false;

(e) whether Borealis had reasonable grounds for believing them to be true; and

(f) what remedy, if any, is available in respect of them.

163. In the paragraphs that follow I set out the relevant history followed by my conclusions as to whether, assuming the matter to be governed by English law, there were any, and, if so, what representations were made, whether they were false and whether they were relied on. I then turn to consider the applicable law.

The representations relied on

164. It is convenient at the outset to set out the representations (some said to have been made more than once) on which, as Mr Justin Fenwick QC on behalf of Kingspan made clear in his final submissions, Kingspan seeks to rely. They are as follows:

a) The representations in Borealis' promotional materials that Borecene grades were fully UV stabilised;

b) The representations in the promotional materials that Borecene was suitable for use in the manufacture by rotomoulding of external oil tanks;

c) The representation in the promotional materials that a good quality coloured Borecene product could be made using dry blending;

d) The representation in the promotional materials that, when changing from conventional material to a Borecene grade, the same pigments could be used in the same quantity;

e) The representation in the promotional materials that Borecene had a broader processing window temperature wise than conventional materials;

f) The representation in the letter of conformity that RM8402, when processed according to good manufacturing practice, was expected to have a weather resistance exceeding 22 GJ/m^2. It is also said that, given that it was later agreed that the figure of 22 GJ should be 37.5 GJ or 34 GJ it was part of Borealis' contractual obligation under Article 35(1) of the Convention on *Contracts for the International Sale of Goods 1980* that RM8402 would have such a weather resistance;

g) The representation contained in a letter of 18 November 2001 that the RM8402 UV package was improved to double the lifetime of the Borecene grades vs. ME8152;

h) The representation in the same letter that adding green pigment would give a lifetime of 10 years for UV exposed products;

i) The representation (made at the meeting on 3 December 2002) that the UV package of RM8402 was closer to UV8 than UV4;

j) The representation (also made at the meeting on 3 December 2002) that RM7402 had passed the UV test in prEN13341; and

k) The representation made by Borealis in the letter of conformity regarding RM7402 that RM7402 was expected to meet the material requirements of OFTEC and prEN13341.

165. These representations are part of a whole raft of representations which were originally pleaded, and which fell into four basic categories (expounded in the 24 pages of Appendix G to Kingspan's opening):

a) representations as to Borecene's superior mechanical properties;

b) representations as to Borecene being "fully UV stabilised";

c) representations that Borecene would provide 22 GJ/m² irradiance in compliance with the OFTEC Standard[24]; and

d) representations as to Borecene's suitability and Borealis' research and development.

As is apparent from the previous paragraph the representations in category (a) are not pursued.

166. Borealis submit that some of the representations set out in para 164 above are either not pleaded or were pleaded but have been withdrawn and invite me not to allow Kingspan to rely on any representations which are in those categories or were never put. I agree with this approach. Any litigant is entitled to know what case it has to answer, in order to decide what questions to ask and what evidence to adduce. That is particularly important in a case of this size. In those circumstances I do not regard it as open to Kingspan to rely on what has not been pleaded or has been withdrawn. Having pleaded their misrepresentation claim on so wide a basis, they cannot justifiably complain of the exclusion of that which they did not plead (or even apply to amend to plead) or which they have disavowed.

[24] Only one of the representations particularised in this category appears to fall within its description.

167. Accordingly I do not regard it as open to Kingspan to rely on representations (c) and (d), which were withdrawn (see Kingspan's response of 2 November 2010 to Borealis' 4th request for further information at para 34). Nor can reliance be placed on representations (i), (j) and (k) none of which are pleaded. In addition representation (k) is contained in a 2004 document and cannot have been relied on in respect of any purchases in 2002 and 2003.

168. As to (e) Mr Jamtvedt was questioned as to whether Borecene could properly be said to have a broad processing window in circumstances where the antioxidant package, it was suggested, had a narrow processing window. But Kingspan in effect confirmed in a letter of 1 December 2010 responding to requests for further information that they were not advancing any criticism of the antioxidant package, and Dr McDaid's evidence was to the same effect. In a footnote to their written opening, Kingspan stated that they had abandoned their case that statements as to the improved processability of Borecene were false. In these circumstances I do not regard it as open to them to rely on this representation. As to (f) the only representation that can be relied on is as to 22 GJ/m^2.

HISTORY

169. In 1996 Titan and Tyrell between them were, and were well known to be, the largest manufacturers of oil storage tanks in the UK. At that time the two companies had for some considerable time been using DuPont SCLAIR 8504 UV8D resin for the production of oil tanks without any significant problems. Although these companies were sizeable users of it, the volume ordered was low in the context of Europe as a whole. Tyrell had also been purchasing material from Borealis and others.

The June 1996 meeting

170. On **20 or 21 June 1996** there was a meeting at PDC's premises attended by Bob Wood, the Rotomoulding Sales Manager of Borealis UK and Mick Shorter, then a senior technical engineer of Borealis, who did not give evidence, and Dessie Gregg of PDC. The purpose of the meeting was for Borealis to introduce Borecene (ME 8166/67) and to persuade Mr Gregg as to its superiority for use in the manufacture of oil tanks.

171. The minutes of this meeting have not survived and there is a dispute as to what occurred at it. According to Mr Gregg's witness statement he informed the Borealis representatives that any new material must be at least the equivalent of DuPont 8504 UV8D. He showed them the specification sheet for it and said that the new material must have at least the equivalent properties, a reasonable processing window, an OFTEC letter of conformity and a UV package that would provide a 10 year life span for the oil tanks. He made it clear that the powder would be dry blended and that the tanks were supplied with a 10 year guarantee. Mr Wood and Mr Shorter listed the advantages of Borecene and assured him they were confident that Borecene would be at least the equal of DuPont 8504UV8D in terms of UV resistance.

172. In his oral evidence Mr Gregg accepted that he probably did not mention UV or UV 8 specifically; nor did he say that Borecene had to contain a UV package which would provide a 10 year lifespan. What he said was that Borecene had to be the equivalent of

DuPont 8504UV8D, whose specification sheet he produced, and Borealis said that Borecene would give Kingspan a better tank.

173. In his written statement Mr Wood referred to making at least one visit before a sample batch was sent to Tyrell but gave no details of what transpired. In his oral evidence he accepted that the aim was to persuade Kingspan of the superiority of Borecene, that he was aware that Tyrell was using DuPont (although he was unaware that UV8 was in the title – he knew it as DuPont 8504). He accepted that he or Mr Shorter said that Borealis' grades were UV stabilised; and that, had he been asked, he would have indicated that Borecene had the same or better characteristics by comparison with Du Pont 8504. He said that Mr Gregg had not said that he wanted Borecene to have as good a UV stability as the DuPont or Dow grades.

174. What I find likely to have happened is the following. The Borealis representatives said that Borecene was at least as good as the DuPont material, the specification sheet for which Mr Gregg produced, and would give Kingspan a better tank. There was no reference to UV 8 or UV stability beyond the fact that the full title of the material - DuPont 8504 UV8D - is on the sheet. The sheet contains no reference in the specification to the UV properties of the grade. I regard it as unlikely that, when referring to DuPont's material, reference was made to its full title. Mr Wood, who knew the Du Pont material as DuPont 8504, would not have done so. Mr Gregg did not say that the material had to be UV8, or that he wanted a UV package to provide a 10 year life span; nor was there any discussion about the significance of UV 8 or about UV resistance or stability. Mr Gregg's evidence was that at this time he did not know what the UV 8 designation meant although at some later stage he came to understand that it referred to 8,000 hours in, he assumed, a WOM of some sort. Nor did he know that tanks could degrade on account of UV light. Even in October 2002 the UV-X rating system was very new to Dr McDaid, whose evidence was that Borealis never mentioned to her that Borecene contained a UV 8 package. Borealis did not use the UV system in its literature or that nomenclature in relation to their UV packages.

175. The discussion was about mechanical properties and passing the test at Athlone; and it was concerned with a grade of Borecene (ME 8166/7) that Kingspan never purchased in any quantity (RM 8402 was not yet available for commercial sale and RM 7402 had not been developed) and which was discontinued in the summer of 1999. Whatever was said cannot have been regarded as a representation about a different product supplied over five years later.

176. Borealis' evidence (Ms Fatnes and Mr Halvorsen), which I accept, was that they did not then, or thereafter, sell their product as UV 8 because this was not a nomenclature that they used at the time.

Discussions with CIBA-Geigy Ltd ("CIBA")

177. At this time the UV stabiliser used by Borealis was Tinuvin 622.

178. Borealis was in discussion with CIBA, an additive supplier, about changing to Tinuvin 783. CIBA's recommendation was that Tinuvin be used at a concentration of 3,000ppm (0.3%). In a fax dated May 15 1996 Mr Muller of CIBA wrote to Mr

Øysaed of Borealis on the subject of *"Stabilisation of black rotomoulded water storage tanks (PP)*". The letter read:

> *"I have discussed with some of my colleagues the requirements you have for rotomoulded water storage tanks (97°C):*
>
> *Generally we recommend 0.3% Tinuvin 783 LLDPE or 0.3% Tinuvin 791 in PP (0.4% Tinuvin 783 if food approval is required) for light stabilisation in rotomoulded systems"*

179. Ms Fatnes' evidence, which I have no reason to doubt, was (a) that she was not aware of having received this because she was not involved very much with polypropylene which was the subject which Mr Øysaed was primarily looking at; and (b) that polypropylene was more prone to degradation than polyethylenes. Kingspan points out that CIBA's recommendation expressly extended to LLDPE (i.e. linear low density polyethylene products). Since Ziegler Natta was an LLDPE, and Borealis treated the stabiliser test results for Ziegler Natta products as relevant to Borecene grades (see, for example, Borealis treatment of the Series E Cytec results – paras 254-5 below), the recommendation was relevant to Borecene. I agree. Professor Malatesta said that, in his experience, stabiliser suppliers would exaggerate the stabiliser needed because it was in their commercial interests to do so. Kingspan invite me to treat this as pure speculation. I do not doubt that such suppliers have no incentive to minimise the amount of stabiliser necessary and an incentive to err on the higher side of caution. Whether any particular recommendation is more than necessary can only be determined by some empirical testing.

27 August 1996: Tyrell trial

180. **Between 21 June and 27 August 1996** Tyrell at Portadown manufactured 6 designs of tanks from ME 8167. The purpose of the trial, so far as Mr Gregg was concerned, was to compare Borecene with the existing DuPont material in order to see whether Borecene could be used to make oil tanks and whether any processing gains (such as reductions in shot weight or cycle time) could be achieved. On 27 August 1996 Mr Shorter, then of Borealis, visited Portadown where Mr Gregg told him that some improvement, predominantly in reduced shot weight, had been witnessed. No UV testing was involved. Kingspan did not have the facilities for such testing. Mr Gregg said at the visit that "*the yes/no criteria [sic] is the passing of the OFTEC standard*". Of particular concern was the deformation test (sections 4.2.6.1/5.2.61) of the OFTEC Standard– the one which was most often failed. Five tanks were to be sent from these production runs to Athlone for testing.

The launch of Borecene

181. Borealis launched Borecene at The Association of Rotational Moulders Conference which took place **between 20 and 22 October 1996** in Vienna. Dr McDaid attended. Ms Fatnes gave a presentation called "*Third Generation of Polyethylenes for Rotational Moulding*". The presentation stated that this third generation of polyethylenes had "*very interesting properties and opportunities compared to traditional LLDPE materials*", and went on to state, amongst other things:

a) *"As a result of faster sintering and crystallisation reduced cycle times up to 30% has been achieved."*

b) *"The materials also gives [sic] very good mould finish, very good internal surface in the mouldings."*

c) *"Material properties are also very good. Environmental stress crack resistance is very good, and also impact and creep properties"*.

182. On **4 December 1996** Andre Van Uffelt, a senior commercial manager, and Ms Fatnes, both of Borealis, attended a further meeting at Portadown. Mr Gregg reported that tests had been done on five different tanks with reduced shot weights and one had failed. Ms Fatnes' note records that "*Tyrell uses much SC/air 8504"* as well as other material. The upshot was that Borealis was to supply 2 tons of ME 8167, 1 ton of ME 8169, and 200 kg each of two other polymers and Tyrell was to test tanks according to an agreed program.

Brochures 1996

183. Borealis, like other material suppliers, produced brochures expounding the virtues and explaining the characteristics of its products, which from time to time it updated or amended. It also produced Product Specifications. In 1996, Borealis published two brochures:

a) *'Rotational Moulding'*, and

b) *'Borecene Polyethylene for Rotational Moulding'*

184. *'Rotational Moulding'* contained the statement that all Borealis grades for "*Rotational Moulding are fully UV stabilised";* and referred to ME 8166/7 as suitable for tanks.

185. In '*Borecene Polyethylene for Rotational Moulding*' Borecene was described as having several advantages when compared with conventional polymers including "*improved flow properties*" and "*improved mechanical properties"* which included "*improved behaviour under constant load (creep)"*. It added:

> *"Reduced weight*
>
> *An advantage of these Borealis polymers for the rotomoulding process, because of the easy flow properties, is the possibility to reduce the weight of the moulded article, due to the even wall thickness control.*
>
> *The powder will flow easier in complicated shapes, and give improved definition."*
>
> *"Why use Borealis Borecene rotomoulding polymers*
>
> *….With these Borecene polymers with a higher Melt Flow you are able to reach the properties of conventional polymers with a lower melt flow. One advantage will be the improvement of material handling"*

December 1996: the 1st Letter of conformity for Borecene

186. As stated in para 142 above, on **22 December 1996,** Borealis sent to Athlone a letter of conformity for several grades, including its Borecene grade ME8166. The letter stated that these grades, "*when processed according to good manufacturing practice, [were] expected to meet the requirements of the [OFTEC Standard]. That is:*

> *"…*
> *5. Weather resistance exceeding 22 GJ (TUVR)"*

1997

187. In **early 1997** PDC carried out trials on, inter alia, (i) 3 tanks made from Novacor 8504, a polymer equivalent to DuPont 8504 UV 8D, and (ii) 2 tanks using model Tyrell 270R, 1 tank using ME 8167 and 1 using Novacor 8504. The tanks were sent to Athlone for deformation testing. Mr Gregg came to the conclusion from the results that there was no significant improvement in performance as a result of using Borecene 8167. As a result further testing was not pursued.

Product specification

188. On **20 June 1997** Borealis produced an Internal Product Specification (IPS) for ME 8160 (later named RM 8402). This specified a target concentration of 1,000 ppm of Tinuvin 622 and a Min/Max of 850 and 1,800. In August 1997 – see the Borealis document headed "*New Borecene Product Mix, proposed 8.8.97*" - this was increased to 1,500 ppm Tinuvin 622 (Min/Max: 1,250/1,750). This was a much lower amount than ME8166, which had a target of 2,500 ppm. Mr Wood, although UK sales manager, was not, and never became, aware that ME8160 had been introduced with this (1,500 ppm) significantly reduced UV package.

August 1997 Borecene strategy meeting

189. On **11 August 1997**, Borealis held an internal meeting in Norway to discuss its strategy for Borecene. Ms Fatnes' minute of this meeting records (highlighting is not in original):

> "**Summary/conclusions**
>
> - *A new product, ME8160, MFR 6 density 940…will be created to cover the interesting applications in addition to the existing Borecene products.*
>
> - ***Reduce Borecene production cost by reducing amount of UV stabiliser if possible**.*
>
> …
> - *Define target applications for Borecene.*
>
> - *Initiate changes in IPS[25] to adjust density of ME8166 and evaluate UV level of ME8166 and ME8160*

[25] Internal Product Specification.

• ***Check UV level needed to guaranty 10 years lifetime*"**

190. It is apparent from these minutes that Borealis was keen to reduce cost by reducing the amount of stabiliser. The fact that UV stabiliser was an expensive additive was a recurring theme as was a concern that the price of Borecene was making Borecene uncompetitive. It is also clear that Borealis was looking for a stabiliser package which would deliver 10 years of UV stability. Ms Fatnes' evidence was that the reference to 10 years lifetime was a general statement not directed at oil tanks. But, even if general, it must surely have included them, not least because of the 10 year reference in the prEN standard and what appears in the next paragraph.

191. The minutes of an internal Borealis meeting on 19 June 1996 written by Ms Fatnes record:

> *"**1. Estimation of long term properties.***
> ....
> *Need normally to estimate properties to approx. 10 years.*
> ...
> ***Actions***
> ...
> *4. Define test program for hoop stress / creep testing for PE for rotomoulding applications. The target is to be able to estimate long-term properties and predict behaviour for a tank or similar."*

192. I infer that the reason for Borealis wanting to be satisfied that the properties of their material would last for about 10 years was because that is the figure that appeared in the prEN standard. I cannot tell whether at this early stage they were aware that tank manufacturers often sold oil tanks with a 10 year guarantee. But I am satisfied that, if they did not know then, they became aware of it later. Ms Fatnes suggested in her evidence that she was unaware that tank manufacturers customarily sold oil tanks with a 10 year warranty until November 2002[26]. But in her statement in the Balmoral litigation she had said:

> *"Borealis at various levels (including myself) were well aware that Balmoral and other tank manufacturers were selling with a 10 year/guarantee."*[27]

Balmoral stopped purchasing Borecene in July 2002.

The Weathering Tests

193. I now turn to the series of WOM exposure tests that Borealis conducted, referred to or relied on from 1997 onwards. Kingspan has identified each series of tests by the letters of the alphabet and I adopt that identification. The results are sometimes presented in the form of graphs or bar charts, which Kingspan has converted into tabular form. These tables are at **Appendix 3** to this judgment. I have amended some of the figures to reflect my findings on the stabilisers involved about which there is, in some cases, a limited area of dispute.

---

[26] "*I was not aware of anyone giving 10 year guarantees*"
[27] Much of her statement in this action is derived from her statement in the Balmoral litigation. But this paragraph was omitted.

August 1997 Series A results

194. On **27 August 1997** Mr Didrichsen of Borealis reported to Ms Fatnes, inter alia, the EaB results after 2,000 and 3,000 hours exposure in Borealis' WOM (0.51 W/m²) of moulded samples of various products, being four Borecenes namely ME 8167 and ME 8169 (both unpigmented) and ME 8177 and ME 8179 (both black); and two ZN's namely ME 8131 (black) and ME 8152 (unpigmented). ME 8152 was Borealis' highest selling general purpose Ziegler Natta[28]. The EaB results, i.e. the percentage by which the specimen had been stretched at break included the following (the percentage of the original is in brackets):

	MFR		Unexposed	2000 hours	3000 hours
ME 8167	3.2	Natural Borecene	460 [100%]	220 [48%]	95 [21%]
ME 8169	6	Natural Borecene	320 [100%]	150 [47%]	90 [28%]
ME 8152	3.6	Natural ZN	260 [100%]	No result	110 [42%]

195. The Borecene tested had Tinuvin 622 at a concentration of 2,500 ppm. As can be seen, both unpigmented Borecenes failed the test after 2,000 hours by which time their EaB was <50%. ME 8167 and 8169 were general purpose grades, not intended for a market with a high UV requirement. Since there was no result at 2,000 hours for the ZN ME 8152 it is not possible to tell whether it had failed by then; although taking the figures on a linear basis it probably had not. At 3,000 hours Borecene performed worse in terms of the percentage of the original EaB percentage than ME 8152, but there was no great difference in terms of the EaB percentages at 3,000 hours. These figures illustrate the EaB test disadvantage point. No tests were carried out on ME 8160/1 – which was to become RM 8402/3. At 3,000 hours the black pigmented Borecenes retained their original EaB and the black pigmented ZN retained 79% of the original. Black pigment (usually compounded) has always been recognised as giving a high degree of UV protection.

November 1997 Series B The Dyno tests Part 1

196. Borealis had a Norwegian customer – Dyno - for which it conducted a series of UV tests on natural and pigmented Borecene grades. The initial tests were carried out on resins exposed to 1,500 hours in Borealis' WOM. The results were provided to Ms Fatnes by Mr Didrichsen on 21 November 1997.

197. These results showed, inter alia, that natural **ME8169** (MFR 6), which became RM 8343, stabilised with 2,500 ppm Tinuvin 622, Borealis' biggest selling Borecene, failed the 50% EaB test after 1,500 hours in the Borealis WOM (something like 1 – 1.5 years' exposure in Scandinavia), at which point it had fallen to 41% of its unexposed value - compared to natural **ME 8152**, the general purpose Ziegler Natta grade, stabilised with 2,500 ppm Tinuvin 622 (ZN used by ROM), which had fallen to 51%. But a reading at 1,000 hours showed that the ZN had fallen to 48% when the Borecene had retained 79% of EaB.

[28] This was not Borealis' ZN grade marketed for use in oil storage tanks, namely ME 8154.

198. Better results were obtained with green pigmented Dyno ZN and Borecene 8169. The results after 1,500 hours were 145% of the original EaB for the ME 8152[29] and 78% for the ME 8169. In each of these cases the actual percentage EaB (as opposed to the percentage of the original percentage) was higher in the case of Borecene. The green pigment appeared to double or treble the lifetime.

199. These results were considered by Borealis to be poor at the time as appears from the following:

i) By email dated **25 November 1997** Dirk Matthijis wrote to Ms Fatnes, Mr Halvorsen, a Borealis moulding engineer, and Mr Goris (amongst others), stating:

> *"It looks that the black material is quite OK however if we need also naturel [sic] material to test natural we need to make new material..."*

ii) On **26 November 1997** Mr Matthijs wrote again to Ms Fatnes, Mr Halvorsen and Mr Goris (among others), saying:

> *"For info.*
>
> *Any comment???? 1year looks to me very little!!!!!!"*

iii) Ms Fatnes responded to Mr Matthijs' observation in the following terms:

> *"1) I agree, 1 year is not much, but it is better to have realistic results. If long outdoor stability is needed, coloured products should be used.*
>
> *2) Our UV stabiliser is maybe not the optimal one. We have tests ongoing at Ciba which we hope will indicate how much extra a change of UV stabiliser can give. Results expected 1Q 98.*
>
> *We also have to be aware that the UV stabiliser is an expensive additive. Increasing the level increases cost."*

200. Despite the results Borealis did not then review its decision to stabilise ME8160 with the lower UV stabilisation package of 1,500ppm of Tinuvin 622. In November 1997 Borealis issued a fresh IPS, with the target Tinuvin 622 concentration remaining at 1,500ppm. Further IPSs for ME8160 were issued in December 1997 and in February 1998 with the same target concentration.

DECEMBER 1997: SERIES A RESULTS UPDATED

201. Updated results for Series A were obtained in **December 1997**. These showed that at 5,000 hours the black Borecenes retained 100% of the original EaB and the black ZN

[29] These results show the imprecision of these tests. The percentage of the original EaB percentage would be expected to dip below 100% (the reference amount) as time goes by. But sometimes it goes up. This may mean a faulty reading or simply a quirk. Further, as is apparent, a reading at 1,000 hours can be marginally worse than one at 1,500.

57%. No further testing (i.e. to 5,000 hours) had been undertaken in respect of the natural resins (ME8167, ME8169 and ME8152) because these resins had already failed the 50% EaB test after 3,000 hours.

Brochure 1997

202. In 1997 Borealis re- issued its *"Borecene polyethylene for Rotational Moulding"* in almost identical terms to the 1996 version.

1998

May 1998 Series B The Dyno tests Part 2

203. On **25 May 1998**, Mr Didrichsen emailed Ms Fatnes updated results in graph form, showing the results for the samples after 3,000 and 5,000 hours of UV exposure in Borealis' 0.51 W/m² WOM. These results revealed, inter alia, the following:

Material		**1000 hrs**	**1500 hrs**	**2000 hrs**	**3000 hrs**	**5000 hrs**
ME 8167 Natural	Borecene	86%	71%	***30%***	-	-
ME 8152 Natural	ZN	***48%***	51%	***38%***	-	-
ME 8152 Green	ZN	-	145%	-	***20%***	***3%***
ME 8169 Natural	Borecene	79%	***41%***	**19%**	-	-
ME 8169 Green	Borecene	-	78%	-	65%	**9%**[30]

204. The tests indicated that natural Borecenes ME 8167 (which failed by 2,000 hours) and ME 8169 (which failed by 1,500 hours) performed better than natural ZN ME 8152 (which failed by 1,000 hours). They showed that the green pigment provided much greater protection than natural polymer for both Borecene and ZN; but also that green pigmented Borecene ME 8169 with Tinuvin 622 at 2,500 ppm was likely to be insufficient to satisfy the EaB test after 10,000 hours in a WOM of 0.35 W/m². Despite this result, a further IPS for ME8160 was issued in 1998, again showing a target concentration of Tinuvin 622 of 1,500ppm.

205. An internal Borealis document dated 5 June 1998 signed by Ms Fatnes included the following results, inter alia:

Material	**50% EaB**	**Expected Lifetime South Florida year**
ME 8152 Green ZN	2,000 hours	1.3.
ME 8169 Green Borecene	3,000 hours	2

[30] It is not possible to tell where between 3000 and 5000 hours failure occurred,

206. The conclusions of the document, which was reissued on 19 May 1999 in the same terms, were these:

> " • *Natural materials, both Borecene and standard materials, have a minimum lifetime of 1 year in South Florida climate.*
>
> • *If long lifetimes with high UV exposure are wanted, use of black or coloured resins are recommended (sic). When chosing (sic) colour it is important to choose one giving good UV stability as differences can be large between the pigments.*
>
> • *Borecene gives equal or better UV stability compared with standard Borealis resins."*

JULY 1998: SERIES C - CIBA TA12106 PROJECT PART 1

207. On **26 June 1998** Borealis representatives had a meeting with CIBA Speciality Chemicals ("CIBA") in Rønningen. On 31 July 1998, Mr Jamtvedt of Borealis distributed a report of the visit, which concerned a joint project between Borealis and CIBA into the UV performance of various UV stabilisers.

208. These tests, which were tensile impact tests, were carried out using the CIBA 0.35 W/m² WOM, which was weaker than Borealis' 0.51 W/m² WOM. They also used stabiliser packages of 2,500 ppm of Tinuvin 622 or 783 (or Cyasorb UV 3346) and not the 1,300 ppm and 1,500 ppm which, as we shall see, came to be used for the Tinuvin 783 in RM 8402 and 7402 respectively.

209. The tests were carried out on 6 specimens. 5 (Specimens B, E, H, I and K) were of ME 8168 (Borecene), which became RM 8342, with different stabiliser packages all at 2,500 ppm. Specimen L was of ME 8152 (ZN) with the same stabiliser package as Specimen B i.e. Tinuvin 622 2,500 ppm; Irganox B215 1,800 ppm. The number of hours to 50% retained tensile strength was approximately as follows:

SERIES C **(CIBA PROJECT TA 12106 - ARTIFICIAL WEATHERING)** **JULY 1998 (1 OF 4)**			**(S3/78)**
GRADES TESTED			**TEST RESULTS**
	MFR	**DESCRIPTION**	**Hours to 50% retained tensile impact strength** ***(CIBA WOM, 0.35W/m²)***
ME8168	6	Specimen B Tinuvin 622, 2500ppm Irganox B215, 1800ppm	*[3250]*
		Specimen E Tinuvin 622, 2500ppm Irganox HP2215, 1500ppm	*[4600]*

		Specimen H Tinuvin 622,2500 ppm Irganox E201, 150ppm Irgafos168, 300ppm	*[5000]*
		Specimen I Tinuvin 783, 2500ppm Irganox B215, 1800ppm	>7000
		Specimen K Cyasorb UV3346, 2500ppm Irganox B215, 1800ppm	>7000
ME8152	3.2	Specimen L Tinuvin 622, 2500ppm Irganox B215, 1800ppm	*[4800]*

210. If Specimen **B** (Borecene/Tinuvin 622) is compared with Specimen **I** (Borecene /Tinuvin 783) the use of Tinuvin 783 instead of Tinuvin 622 could be said at least to double the lifetime of the resin. However, CIBA's report of the results refers to Sample B giving a worse performance than the others stabilised with Tinuvin 622 "*probably due to worse process stabilisation*". If so, the comparison would not be sound evidence of a doubling of the lifetime by the use of Tinuvin 783. A comparison between Borecene Specimens E or H/Tinuvin 622 (where the antioxidant package was not identical) and Borecene Specimen I/Tinuvin 783 would show increases of at least 52% and 40%.

211. A comparison between Specimen L (ZN/Tinuvin 622) and Specimen I (Borecene/Tinuvin 783), where the Irganox content is the same, would show at least a 45% increase in hours to failure in the Borecene/783 material. On any view Tinuvin 783 was an improvement and, since the reading for Specimen I was ">7000" the full extent of the improvement was not apparent.

212. These comparisons assume that there is a linear relationship between performance and Hals concentration, a matter to which I revert in para 453 below.

The retreat from Tinuvin 622

213. Towards the end of 1998 Borealis began to specify a higher level of Tinuvin 622 for ME 8160. The IPS for ME 8160 dated 25 September 1998 has the 1,500 target figure changed in manuscript to 2,500 (although there is another annotation on the present copy of the document in what looks like a different hand which restores the 1,500 figure). On 15 October 1998 a further IPS was issued in typescript showing a target loading of Tinuvin 783 at 2,500.

October 1998: SERIES C - CIBA TA12106 PROJECT PART 2

214. In **October 1998** Mr Jamtvedt of Borealis received a further set of results relating to the TA 1206 project. These were tensile impact tests on samples exposed to weathering in Florida i.e. not in a WOM. The conclusion of the tests, on specimens with the same characteristics as those used in the artificial weathering tests (i.e. as in

Specimens, B, E, H, I, K and L) was that after 1 year of Florida exposure no differentiation could be made between the different stabiliser systems and both metallocene and traditional polymers were still doing well.

215. These results did not found any basis for suggesting that switching from Tinuvin 622 to 783 would double the lifetime of tanks. They dealt with concentrations of 2,500 ppm, not 1,500 or 1,300.

1998

Brochures in 1998

216. In 1998 Borealis republished "*Rotational Moulding"* which continued to describe Borecene grades as "*UV stabilised*" (without the "*fully*") and ME 8166 as suitable for the manufacture of tanks. It was republished in the same terms in 1999.

217. Borealis also published the "*Borecene Processing Guide"* which stated that Borecene had improved mechanical qualities relative to conventional polyethylenes including improved ESCR and improved creep properties, especially at high temperature and that it could maintain mechanical properties at higher MFR. The guide makes clear that Borecene was developed for rotomoulding for various applications including fuel tanks. The Processing Guide repeated the claim that all Borealis grades were fully stabilised.

218. It also contained the following:

> *"Sintering*
> *Because of the lower viscosity and easier flow of molten Borecene an even distribution of polymer in the mould will be achieved at a lower temperature, allowing the heating to be stopped earlier for Borecene than for conventional materials. This results in excellent sintering at lower air peak temperatures, thereby saving energy as well as shortening the overall heating time in the oven.*
> *For Borecene MFR=6 material it is possible to stop the heating at a temperature of about 165 degrees while for standard materials the heating normally needs to be continued to a temperature of 185 degrees"*

Material	*Sticking*	*Melting*	*Needed Sintering Interval*
Borecene MFR 6	*90-110*	*110-130*	*130-165*
Borecene MFR 3	*90-110*	*110-130*	*130-175*
Conventional	*75-110*	*110-130*	*130-185*

The sintering/PIAT table was slightly altered in the 2000 version of the Guide.

The December 1998 Meeting

219. On **8 December 1998** a meeting took place between Mr Halvorsen and Mr Wood of Borealis and Dr McDaid and Mr Gregg of Kingspan. Borealis sought to introduce ME

8160/1 (which became RM 8402/3) to Kingspan and to persuade PDC of its technical benefits.

220. Mr Gregg did not recollect everything that was said. In his witness statement he recalled repeating that what Kingspan was interested in establishing was whether the new grades of Borecene were at least equal to or outperformed DuPont 8504 UV8D in terms of material properties, which to his mind included UV resistance. But in cross examination, when presented with Dr McDaid's notes of the meeting, which make no mention of UV or UV8 or DuPont 8504, he accepted that the likelihood was that he had not said this. Cost was also raised, Mr Wood saying that Kingspan should be paying a premium for Borecene as it was a premium material and would lead to savings in processing time and shot weights.

221. In his witness statement Mr Wood said that there was no discussion about whether Borecene had a UV 8 package. The most he would have said at this meeting was that Borecene contained a stabiliser package which comprised an industry recognised additive, which had been tested and which performed at least as well, if not better than, Borealis' previous ZN grades ("the stabiliser package statement"). He had learnt this from Ms Fatnes, who had told him that Borecene was as good as, if not better than, the Ziegler Natta grades. There was however no discussion about UV or about Borecene having a UV 8 capability. Mr Halvorsen's evidence is that he would not have commented on DuPont UV8D without having gone away and checked whether it compared first.

222. In the light of that evidence I do not regard it as established that Mr Gregg (or Dr McDaid) said that Borecene had to be at least as good as DuPont UV8 or that there was any significant discussion about UV resistance characteristics. But Mr Wood probably did make the stabiliser package statement.

223. Dr McDaid's evidence which I accept was that Mr Wood and Mr Halvorsen emphasised, inter alia, the reduced cycle time including the fact that the product could be moulded at a lower PIAT; and specifically recommended in February 1999 a PIAT of 175° C.

224. As a result of this meeting PDC decided to proceed with further investigation into Borecene materials. PDC agreed with Borealis that tanks made in trials that were to take place would be sent to Athlone for testing.

1999

February 1999 *IPS for ME 8160*

225. Another IPS for ME 8160 was issued on **23 February 1999**. It specified a target content for Tinuvin 622 of 1,500 ppm[31]. On **9 March 1999** Ms Fatnes sent a fax to a colleague in which she indicated that ME 8160/1 would contain Tinuvin 783 at between 1,000 and 3,000 ppm. She asked "*what tests and samples are needed to get the new products approved*".

[31] In the light of the 9 March 1999 fax it may be that the use of the Tinuvin 622 printed form was a mistake.

226. On **25 February 1999** trials took place at Titan using ME 8161 (the powder version of ME 8160), 1 tonne of which Borealis supplied free of charge. This was dry blended with green pigment. Two tank types (LP 1200 and H 1250) were moulded in Borecene and Dow 2432. Mr Wood and Mr Halvorsen attended those trials on behalf of Borealis. The oven time was set to achieve a PIAT of 175° C. PDC were told that ME 8161 was the replacement grade for ME 8167, which had been trialled in the summer of 1996. Mr Gregg in his witness statement recalled that the assurances previously given in relation to ME 8167 were repeated for ME 8161; but it is not clear to me exactly what he was claiming to have been said and, as appears in paras 170 - 176 above, I do not accept that Mr Gregg's evidence about the June 1996 meeting was accurate. There is no reference in either of the notes of the February 1999 meeting or in Dr McDaid's evidence to any particular assurance or representation. Dr McDaid's note of the trial records that "*The material moulded very well in a number of ways*". Another Kingspan note records that "*The MFI of 6 is very beneficial for processing, the sintering time is significantly reduced and hence the required cooking time is shorter*".

227. On **3 March 1999** 4 tanks (2 of each type) were sent to Athlone to start the 42 day deformation test.

MAY – JULY 1999: BOREALIS' FURTHER INVESTIGATIONS INTO UV STABILISERS

228. On **14 April 1999**, Mr Jamtvedt of Borealis emailed Mr Vulic of Cytec, another large additives supplier, suggesting test formulations using Tinuvin 622 and 783. It was proposed that the loading level would be maintained at 2,500 ppm, for both Tinuvin 622 and 783. On 6 May 1999, Mr Vulic emailed Mr Jamtvedt proposing that test runs be carried out on various additive packages, including:

a) Tinuvin 622 at a concentration of 2,500 ppm (the reference specimen);

b) Tinuvin 783 at a concentration of 1,750 ppm; and

c) Cyasorb UV- 4611 at 1,750 ppm in two versions.

This proposal suggested that Tinuvin 783 was approximately 40% more powerful than Tinuvin 622, which was consistent with the Series C Part 1 CIBA results of July 1998.

229. On **13 July 1999**, Roger Goris of Borealis wrote to Chantal Monfrére[32] of ICO Diegem, copying Mr Webster, Borealis' then General Sales Manager for Rotomoulding. He stated that in recent EaB tests the UV results as a very conservative estimate indicated a lifetime of 2.5 years for the natural Borecene, a lifetime of 7 years for black Borecene, with coloured Borecene somewhere between the two. Figures produced by CIBA with a life time based on impact strength resulted in higher figures for Borealis than those based on EaB. He went on to say:

> *"I discussed issue [sic] with John Webster recently and agreed there urgenty [sic] is a need to make an official Borealis statement/leaflet about life time.*

[32] The wife of Mr Shorter.

We will do this with priority. I can not [sic] give a dead line [sic] now. It depends of [sic] the decision if we want to make extra tests or not.

For the time being please use the figures as mentioned above."

No such statement was ever made.

JULY 1999: SERIES D

230. In **July 1999**, Borealis obtained a further set of results (Series D) from tests in their WOM, in relation to which Ms Fatnes produced a report. The tests were run on ME 8160 (later RM 8402) with Tinuvin 783 at levels of 1,500 and 2,500 ppm and on an ME 8161 reference sample with 1,500 ppm Tinuvin 622. These were target concentrations. The actual concentrations were 1,415 and 2,760 ppm. The results showed that, after 2,500 hours of UV exposure using Borealis' WOM:

i) the EaB value for the ME8161 sample with a Tinuvin 622 concentration of 1,500 ppm had fallen from approximately 1,320% to approximately 810% (and hence was approximately **61%** of its initial value);

ii) the EaB value for the ME8160 sample with a Tinuvin 783 concentration of 1,415 ppm had fallen from approximately 1,450% to approximately 900% (and hence was approximately **62%** its initial value); and

iii) the EaB value for the ME8160 sample with a Tinuvin 783 concentration of 2,760 ppm had fallen from approximately 1,120% to approximately 810% (and hence was approximately **72**% its initial value).

There was, thus, a small improvement in the performance of Borecene when Tinuvin 622 at a concentration of 1,500ppm was replaced with Tinuvin 783 at a concentration of 2,760 ppm (61% to 72%), but there was no material difference in the performance of Borecene when Tinuvin 622 at a concentration of 1,500ppm was replaced with Tinuvin 783 at a concentration of 1,415 ppm (61% and 62%).

231. Kingspan submits that, since these results suggested that (i) Tinuvin 783 at a concentration of 1,415ppm, and (ii) Tinuvin 622 at a concentration of 1,500ppm afforded approximately the same level of UV protection, they provided no reasonable basis for believing that using Tinuvin 783 at a concentration of 1,415ppm would provide the same protection as Tinuvin 622 at the higher concentration of 2,500 ppm. Moreover:

i) Given that Borealis were deciding whether to replace their existing additive package of Tinuvin 622 at a concentration of 2,500 ppm with some alternative formulation, it was odd that Borealis chose to use as its reference resin a Borecene stabilised with Tinuvin 622 at a concentration of 1,500ppm;

ii) The results provided no basis for the assertion that Tinuvin 783 at a concentration of 1,415ppm (still less at a concentration of 1,300ppm) would double the lifetime of a resin otherwise stabilised with Tinuvin 622 at a concentration of 1,500ppm; and

iii) There was an oddity in these results, in that the EAB value for the specimen stabilised with Tinuvin 783 at a concentration of 2,760ppm appeared to *increase* after 1,500 hours exposure. Dr Botkin indicated that if he were advising Borealis, he would have told them to do these tests again.

232. The conclusion that Ms Fatnes drew from the results in her technical report, which seems to me appropriate in the light of the data, was that:

> *"The results indicate similar or slightly improved UV stability for Tin 783 both at 1500ppm and 2500ppm levels. compared to the reference material ME8161 which has 1500ppm Tinuvin 622 after WOM testing for 2500 hours. There seems to be little to gain from increasing UV level from 1500 to 2500ppm."*

233. Her report also showed the results of an earlier test on ME 8167 and ME 8169 with Tinuvin 622 at 2,500 ppm where by 2,500 hours both samples were down to 29%.

234. On **4 June 1999** Athlone produced a report on the four Borecene tanks referred to in para 226 above (and on 8 tanks made from other material) which concluded that the H1250 and LP 1200 models met the requirements of Sections 4.2.1 to 4.2.8 of the OFTEC Standard in all respects. The report stated that :

> *"In accordance with OFTEC regulations a full pass in Borecene material can be issued across the whole of the Titan range once a letter of conformity has been received by the testhouse*"

The tests which had been requested and carried out were the tests on the constructional requirements of the Standard.

235. The Athlone report related to RM 8402 and was for Titan. There is some evidence of a submission by Tyrell of an RM 8402 245 tank to Athlone (see para 484 below) but it seems to me unlikely that any such report was ever given. There is no evidence of the submission of any RM 7402 tanks to Athlone or of any report from Athlone in response in either 2002 or 2003.

236. The effect of this was that only two types of Borecene made tanks were tested. Whilst this was what the Standard permitted I agree with Mr McDonald, Borealis' tank design expert, that it is unsatisfactory (in his view "*alarming to say the least*") for Kingspan to obtain a blanket certification for all their products made from Borecene when only two different shapes had been tested. These did not include any of the tanks which, made from ZN, had had a relatively high failure rate e.g. R 245.

AUGUST 1999: BOREALIS ISSUES LETTER OF CONFORMITY FOR RM8402

237. On **18 May 1999**, Dr McDaid, having learned that Borecene had passed the tank constructional requirements during tests carried out at Athlone, sent a fax to Mr Wood of Borealis asking him to issue a letter of conformity in respect of the OFTEC material requirements. Her fax pointed out that materials that pass the OFTEC tank test must also comply with the material requirements of the standard and that it was only after receiving a letter from the material manufacturer that OFTEC could give a full pass on new tank material. She attached the draft referred to in para 124 above.

The change in stabiliser package

238. By mid-1999, Borealis was considering a change in the UV stabiliser to its Borecene products. On **27 July 1999**, Ms Fatnes wrote to various of her colleagues at Borealis, including Mr Halvorsen and Mr Jamtvedt, stating:

> *"We plan to change the UV stabiliser in our Borecene products to improve performance and reduce cost. New IPS's will be issued (Responsible: AMF)*
>
> ***The change will be implemented from 1.9.99 if possible, or as our soon as our stock of the old stabiliser (Tinuvin 622) is empty.***
>
> *The following changes are planned:*

Product	***New UV/amount***	***Old UV/amount***
ME8160	*Tinuvin 783/1300ppm*	*Tinuvin 622/1500ppm*
ME8168	*Tinuvin 783/1500ppm*	*Tinuvin 622/2500 ppm*
ME8164	*Tinuvin 783/ 1300ppm*	*Tinuvin 622/ 2500ppm"*

[Bold added]

Ms Fatnes believed, on the basis of the results obtained with 1,415 ppm of Tinuvin 783 that the reduction of c 100 ppm from 1,415 ppm would not make a significant difference to the UV stability of RM 8402[33] and would have cost benefits. The same UV performance as for the ZN grades would be achieved but at a lower cost.

239. By email dated 4 August 1999 Ms Fatnes wrote to Mr Leif Rehn, also of Borealis, in relation to the requested letter of conformity. Her email stated:

> *"You issued a "letter of conformity" for Borealis Rotomoulding grades to the OFTEC in 1995. We need to add the newest Borecene grade(s) to that list.*
>
> *In specific [sic] it is asked by one customer for our grade ME8160.*
>
> *What do you need to issue this for our new grades?"*

240. On **5 August 1999** Mr Ervik of Borealis Norway faxed a letter to the Chairman of the CEN Committee. He told him that, based upon experience, Borealis knew that tanks made from Borecene would not retain 50% EaB when exposed to a total irradiance of 22 GJ/m^2 but that, since Borecene had very good mechanical properties, it could have an EaB which was 15% of initial EaB and still withstand the minimum requirement (presumably 22 GJ/m^2) for unexposed (sic) material. He asked for an exception.

[33] Professor Malatesta agreed on the basis that when the concentration of a stabiliser is doubled its efficacy is not doubled but increased by a factor of 1.41 (the square root of two). See further para 454 below.

241. By a fax dated 9 August 1999, Ms Fatnes sent Mr Rehn a copy of the OFTEC standard and "*copy of request for "letter of conformity" for Borecene ME8160/61 (MFR 6,0, density 940.)"* Ms Fatnes went on to state:

> ***"As discussed the UV criterias (sic) cannot be met with natural material, but should be OK for the green pigmented material that is used for the tanks.***
>
> *Please issue a letter of conformity for ME 8160/1 and send to Julia McDaid…"* [Bold added]

242. A copy of the OFTEC standard was faxed to Mr Rehn that day. The document has a manuscript notation against section 4.1.6 that 8,000 hrs is the equivalent of 500 kilolangleys[34]. It was originally suggested that this was a non contemporaneous annotation. But that suggestion was withdrawn. It is inconsistent with the presence of the note on two copies of the document, one with and one without the fax insignia. The date of the annotation must be no later than 9 August 1999 when the fax was sent and the likelihood is that it is in Ms Fatnes' handwriting, and that the calculation was made in order to get some idea of what the OFTEC weathering threshold in Klys represented in terms of WOM exposure[35].

243. By a fax dated **12 August 1999**, Mr Rehn sent Ms Fatnes "*the requested OFTEC Statements regarding the Borealis Polyethylenes ME8160 and ME8161*". The letters of conformity stated:

> *"This is to inform you that the Borealis Polyethylene ME[8160][8161] as supplied to PDC, when processed according to Good manufacturing practice, is expected to meet the requirements of the OFTEC Oil Firing Equipment Standard OFS T100 (may 1994). That is*
>
> *…*
>
> *5. Water [sic] resistance exceeding 22 GJ (TUVR)."*

244. On **16 August 1999**, Mr Rehn issued a new version of the letters of conformity in relation to ME8160/1, which referred to ME8160/1 as supplied to the Kingspan Group rather than PDC, and corrected the typographical error at point 5 ("Water resistance") to read "Weather resistance".

245. It is apparent from the faxes of 5 and 9 August 1999 that Borealis believed that natural Borecene would not meet the <50% EaB after 22 GJ/m² test and that meeting that test was dependent on pigment.

246. It is not clear to me on exactly what basis Borealis felt able to give the letter of conformity at this stage. The results of tests in a Borealis WOM - where 22 GJ/m² would equate to around 6,200 hours - on *natural* Borecene with 2,500 ppm Tinuvin 622 had shown that ME 8169 (MFR 6) failed at 2,000 hours (Series A) or 1,500 hours (Series B). In the Series C tests in a CIBA WOM - where 22 GJ/m² would equate to a

[34] Close to 20 GJ/m². 8,000 hours in a Borealis WOM would represent nearer 26 GJ/m². For 22 GJ/m² the time required in a WOM of 0.35 m² is a little under 9,000 hrs.

[35] In her email of 17 November 1999 to Mr Andreev (see para 254 below), Ms Fatnes suggested to him that ME 8160 lasted about 4,000 hours in the WOM equal to about 250 Kly. This is the same conversion rate as used in the annotation.

little under 9,000 hours -. ME 8168 (Specimen I) with 2,500 ppm of Tinuvin 783 had not failed by 7,000 hours. But what was proposed was 1,300 ppm Tinuvin 783. However, the Series D tests in a Borealis WOM had shown that the difference between 1,415 and 2,760 ppm was not that great. In Series D *natural* ME 8160 (RM 8402) had not failed by 2,500 hours in a Borealis WOM with 1,415 ppm of Tinuvin 783. But, if that was extrapolated forward linearly 50% EaB would be reached after about 3,000 hours.

247. Green pigment could be expected to increase weather resistance. In the case of Series B in the Borealis WOM ME 8169 had not failed at 3,000 hours, but had failed by 5,000 hours.

248. The likelihood, as it seems to me, is that Borealis felt able to sign the Letter because of (i) their previous satisfactory experience with ME 8152; (ii) the Series C and D results themselves; and (iii) a 2-3 fold factor to allow for pigment. They may also have relied on the similarity of performance between Tinuvin at 1,415 and 2,760 ppm in Series D to draw comfort from the results for Specimen I (Tinuvin 783 2,500 ppm) in Series C.

SEPTEMBER 1999: OFTEC MEETING

249. On **15 September 1999**, the Tank Committee met. Mr Gregg attended on behalf of PDC and Ms Fatnes on behalf of Borealis. Mr Shorter was also in attendance but, by this stage, he had begun working for ICO Polymers. The incorrect conversion of the irradiance threshold in the OFTEC weathering standard from kilolangleys was discussed. The minutes of the meeting record:

> *"(d) It was agreed that Clause 4.1.6 of OFS T100 contained an incorrect measurement. The figure 22 giga joules per m^2 was shown as the equivalent of 900 kilolangleys. This was incorrect, and should read 37.5 g^3/m^2. BR agreed to pass the relevant minutes of the TC266 European Committee meeting to A-MF and/or MS for confirmation after which DG will produce a new paragraph."*

DG is Mr Gregg, who does not appear to have produced such a paragraph.

250. The figure of 900 Klys had been based on a CIBA world radiation map which showed an average annual radiation across Northern Europe of 80/90 Klys per year. Someone connected with CEN had obviously miscalculated the conversion to GJ/m^2. The CEN technical committee later agreed that 80kLys per year was more appropriate and in the later draft of the prEN standard of June 2001 the GJ/m^2 value was reduced to 34.

251. Borealis was seeking to amend prEN1334 so as to permit a higher MFR than the 5 specified in the then current draft, in order to accommodate Borecene. (The 5 MFR limit had originally been set on the basis that higher MFR grades were traditionally associated with reduced physical properties). On **24 March 1999** Ms Fatnes had sent Dr McDaid and Mr Gregg of PDC a fax proposing that the CEN standard be adapted in the same way as OFS 100 had been changed. Mr Gregg was a member of the CEN Committee. Mr James McGreer was its Chairman. On **21 September 1999**, Ms Fatnes wrote to Mr McGreer, with a copy to Dr McDaid, to request that the CEN Committee consider extending the MFR window to MFR 6 grades, so as to

accommodate the higher MFR of the new Borecene materials. She attached a report of hers entitled "*Comparison between Borecene and standard rotomoulding grades*" which represented that the higher melt flow properties did not reduce Borecene's properties and stated:

> *"The results show clearly that Borecene has equal or improved properties in all areas. Borecene grades have excellent mechanical properties in spite of having higher MFR. Borecene is superior to standard grades when it comes to*
>
> - *Sintering properties/cycle time reduction potential;*
> - *Impact properties;*
> - *Environmental Stress Crack Resistance (ESCR);*
> - *Long term creep properties."*

The report was silent as to weathering properties.

252. It was Dr McDaid's evidence that she understood this statement as follows:

> *"... it confirmed for me in particular Borealis were confident in their 6 melt Borecene material. This was given to me in the context of their request to widen MFR specification, and thereby that confirmed to me that they had confidence in the grade as being suitable for rotomoulding of oil storage tanks, and this information was background, background information and confirmed those messages."*

253. Ms Fatnes wrote to Dr McDaid on **1 November 1999** and made various statements about the properties of Borecene. Her email stated:

> *"[Their] attributes gives [sic] polymers with improved properties compared with conventional catalyst...Properties which are improved are for example impact, creep and ESCR properties....Borecene and other metallocene based polyethylenes have improved properties in many ways, but they are still polyethylenes There is every reason to believe that their long-term properties will continue in line with the way they do for standard materials."*

Mr Gregg's evidence was that he understood that this meant that Borecene, notwithstanding its higher MFR, would fully comply with the material requirements of prEN 13341.

NOVEMBER 1999: SERIES E - CYTEC TEST RESULTS

254. By November 1999 Borealis had obtained a further set of EaB test results from Cytec. On **18 November 1999**, Ms Fatnes emailed Nikita Andreev, Borealis' Russian representative, the results which were set out in two slides. They were provided to Mr Andreev in response to a request to Ms Fatnes from Mr Webster for data on the UV performance of Borecene as against standard resin in order to keep "*Nikita's customer happy"*. The tests compared the performance of Cyasorb UV 3346, Tinuvin 622 and Tinuvin 783 at a concentration of 3,000 ppm as a stabiliser for an unidentified ZN material.

255. The results showed that, at that concentration, Tinuvin 622 would fail (i.e. reach 50% of original EaB) at 3,760 and Tinuvin 783 at 8,970 hours in the CIBA 0.35 W/m² WOM. These results were encouraging so far as a comparison between Tinuvin 783 and Tinuvin 622 was concerned. However, the testing was carried out at 3,000 ppm on a ZN grade; and the results were inconsistent with the Series D results where ME 8161 at a concentration of 1,500 ppm Tinuvin 622 and ME 8161 at a concentration of 1,415 ppm Tinuvin 783 showed no material difference in performance of the two stabilisers.

DECEMBER 1999: SERIES C - THE CIBA TA12106 PROJECT PART 3

256. On **8-9 December 1999**, a Borealis meeting was held at Rønnigen to discuss, amongst other matters,[36] Project TA12106. The updated results for the tensile impact strength testing of specimens exposed to natural (Florida) UV in relation to project TA12106 were distributed.

257. The results showed that, after 2 years of Florida exposure, Specimen L - the Ziegler Natta specimen (ME8152) outperformed all the Borecene specimens (B, E, H, J, K) in terms of percentages of original retained tensile impact strength (retaining approximately 93% of its original tensile impact strength). The relevant Borecene percentages were: Specimen B 78%; E 91%; H 73%; I 79%; K 89%. In this test Specimen I (stabilised with Tinuvin 783 at a concentration of 2,500ppm) did not significantly outperform any of the specimens stabilised with Tinuvin 622 at a concentration of 2,500ppm.

DECEMBER 1999: SERIES F - THE CIBA TA 12492 PROJECT

258. In parallel with the TA12106 CIBA joint project, Borealis was running a further project with CIBA comparing base stabilisers (TA 12492). Weathering tests were carried out in a CIBA WOM on Borecene ME 8168, stabilised with different additive packages all but two of which included Tinuvin 622 at 2,500 ppm. The Ziegler Natta resin ME8152 was used for reference purposes. The test results were discussed in the course of Borealis' meeting with CIBA on 8-9 December 1999.

259. These results, based on retained impact strength, showed that:

i) After 6,000 hours in the CIBA WOM Specimen 1 (Borecene ME 8168 with Tinuvin 622 at a concentration of 2,500ppm) had only around 11% retained impact strength;

ii) After the same exposure Specimen 12, the Ziegler Natta reference sample with the same additive package as Specimen 1, outperformed Specimen 1. It had around 73% retained impact strength; and

iii) After 10,000 hours Specimen 5 (Borecene with 2,500 ppm Tinuvin 622 with a different antioxidant package) had retained 62%; and Specimen 8 (Tinuvin 622 1,250 ppm and Chimassorb 2020 1,250 ppm and different antioxidants) had retained 77%, whereas the ZN had failed at 8,000 hours (17%).

[36] Progress on TA12492 was also discussed: see para 258 below.

The toolbox

260. On **10 December 1999**, Mr Halvorsen sent an email to Ms Fatnes and Mr Ervik (amongst others), indicating what UV values should be in the Borealis Toolbox (i.e. the electronic database accessed by the technical team). In relation to natural Borecene, he stated:

> *"Natural 4000h in WOM = 250 Kly; Lifetime approx 4 years in Scandinavia, 3 years in mid-Europe, 2 years in Southern Europe, 1.5 years in California*
>
> *The values are based on: Elongation to break, <50% decrease*
>
> *Colours:*
> *Most of the colour based materials are unchanged after 5000h WOM. This gives a lifetime more or less as for black materials: Approx 20 years in Southern Europe.*
>
> *Just be aware, it's very much depending on what kind of pigment used*
>
> *New add.package for Borecene seems to give twice the lifetime we have today for natural grades.*
>
> *We will update the Tool Box when the test is finalised – in one year time"*

2000

MAY 2000: BOREALIS ISSUES RM7402 SPECIFICATION SHEET

261. In May 2000, Borealis published its Borecene RM 7402 specification sheet, which included the statement that "*the additive package is specifically formulated for rotational moulding*" and that "*the polymer is fully UV stabilised and contains long term antioxidant*".

MAY 2000: BOREALIS PROCESSING GUIDE

262. In June 2000, Borealis published a further version of the *Borecene Processing Guide*. The Guide said (in terms very similar to those which had appeared in the 1998 version):

> *"As with standard materials,* ***a coloured Borecene product can be made either by using a coloured compound, or by dry blending with colour pigments or a master-batch.*** *The best quality is obtained with the former method, which not only gives the most homogenous colour but also the best mechanical properties in the formed item.*
> ***However, good quality colouring can also be achieved through dry blending****. As with standard materials, pigments which are stable in the rotational moulding process should be used. Their selection is also based on the need for adequate pigment dispersion through the formed item.*
> ***When changing from a standard material to a Borecene grade, the same pigments can be used, in the same quantity****: The colour may appear brighter*

and glossier as Borecene grades do not yellow so quickly when overcooked. Internal investigations have shown that for the pigments studied these pigments have less effect on shrinkage rates in Borecene, due to nucleation and crystallisation, than in standard materials.
It is recommended that the quality of the Borecene product is initially monitored to ensure correct pigmentation. Details regarding pigments can be supplied by the pigment manufacturer." [Bold added]

OCTOBER 2000: SERIES G

263. By email dated Monday 30 October 2000, Mr Didrichsen emailed Ms Fatnes a set of UV test results (both EaB and Tensile Impact strength) conducted in a Borealis WOM on ME8152 (ZN), and Borecenes ME8169 and ME8161, the previous number for RM 8403. The results were:

SERIES G OCTOBER 2000			**(S6/119)**							
GRADES TESTED			**Type of Testing (*Borealis WOM – 0.51 W/m²*)**							
	MFR	**DESCRIPTION**	***Tensile Impact Strength (ISO8256)***				***Elongation to break (ISO 527)***			
			0 hours	**1000 hours**	**2000 hours**	**3000 hours**	**0 hours**	**1000 hours**	**2000 hours**	**3000 hours**
ME8152	3.6	With Tin 622, 2500ppm	189	242	225	215	*[690]*	*[75]*		
			(100%)	(128%)	(119%)	(114%)	(100%)	(11%)		
ME8161 (RM8403)	6	With Tin783, 1300ppm	272	254	215	140	*[1280]*	*[980]*	*[680]*	*[580]*
			(100%)	(93%)	(79%)	(51%)	(100%)	(77%)	(53%)	(45%*)
ME8169 (RM8343)	6	With Tin 783, 1500ppm	340	330	290	280	1290	970	677	619
			(100%)	(97%)	(85%)	(82%)	(100%)	(75%)	(70%)	(64%)

264. These results had some surprises. The tensile impact strength of ME8152 (ZN) appeared to *increase* after being exposed to 1,000 hours of UV in the Borealis WOM and was still greater than the reference value after 2,000 and 3,000 hours. But its EaB appeared to fall very dramatically after 1,000 hours of testing.

265. The bar charts in which the results are expressed do not indicate, and there is a dispute, as to what the stabiliser package was. Kingspan suggests that the likelihood is

that it was the one applicable before the change implemented in 1999. This is because the reference numbers for the Borecene are the "old" numbers (ME 8169 became RM 8343, ME 8161 became RM 8403) and because in an e-mail of 6 November 2000 (which Kingspan suggests is likely to have been in reply to Ms Fatnes' email of 30 October 2000) Mr Didrichsen confirmed that the samples for ME 8161 and 8169 were placed in the WOM on 6 July 1999 i.e. before the change which was due to take place on 1.9.99, if possible but which appears to have taken place, so far as production was concerned, from 1 November 1999: see Ms Fatnes email of 17.11.99. If so the ME 8152 ZN would have been stabilised with Tinuvin 622 at 2,500 ppm as would the ME 8169 with the ME 8161 having 1,500 ppm.

266. I think this is unlikely. The evidence is confusing (and Ms Fatnes was confused at the time – see her email of 3 November 2000). But Mr Didrichsen's email of 6 November 2000 (and an earlier one of 19 October 2000) indicates that in October 2000 there was more than one set of tests going on. The 6 November 2000 email refers to ME 8167, 8161 and 8169 as having been placed in the WOM on 5 July 1999. The email of 19 October 2000 refers to ME 8169, 8161, and 8167 having been exposed for 7,500 hours (far less than exposure from 5 July 1999) and the results so far as showing no significant reduction in EaB. Whatever these emails are referring to, it cannot, in the case of ME 8161 (=RM 8403), be the tests whose results appear as Series G for two reasons: (a) the Series G results only went to 3,000 hours; and (b) the results showed at 3,000 hours a significant reduction in EaB.

267. Both emails also refer to the exposure of ME 8169/RM 8343 with a new UV package. The email of 6 November refers to that exposure starting on 15 Jan 2000. The email of 19 October 2000 refers to ME 8169 with new UV packages (sic) having spent 5,000 hours in the WOM and adds: "*I believe we'll wait until we get to 7,500 hours before we begin tests because there is little testing material*." This cannot be a reference to the Series G tests because they only went to, and were reported as at, 3,000 hours. What the emails do show is the continued use of the old name - ME 8169 – after the change.

268. The minutes of the Borealis meeting of 24 October 2000 record that the "Background" to the meeting included

> *"• New UV package for Borecene was implemented Q 4 99. Test results to verify performance is needed.*
>
> *• Tests started on samples compression moulded from rotomoulded boxes, both with new and old UV packages. These samples give a UV performance of >2x "old" results for rotomoulded boxes/Elongation to break measurements."*

The minutes then record that Mr Didrichsen "*presented results from comparing results achieved with Elongation to break tests v Tensile Impact tests. Also latest test result with Compression moulded samples were discussed*".

269. In my judgement the likelihood is that there were at least three sets of tests. One was on rotomoulded samples with the new UV package. Two were on samples compression moulded from rotomoulded boxes both with the new and the old package. The October and November emails from Mr Didrichsen refer to these compression moulded tests – hence the reference in the 6 November 2000 email in

respect of samples placed in the WOM on 5 July 1999: *"Bente Ida pressed plates from RM boxes and stopped the samples"* and in relation to exposure with a new UV package *"again Bente Isa pressed plates here"*. The Series G results on which Mr Didrichsen reported on 24 October 2000 and which he emailed round on 30 October were the test results (now available up to 3,000 hours) on the rotomoulded samples with the new UV package which were needed to verify its performance – as recorded in the Background section of the minutes. I have accordingly altered Kingspan's table so as to include the new and not the old stabiliser package.

270. Kingspan drew attention to a number of features of the results including the following[37]:

a) *In relation to the tensile impact strength tests:*

i) ME 8152, the Ziegler Natta grade, substantially outperformed both Borecene grades in percentage terms;

ii) The results for ME 8161 and ME8169 implied that reducing the quantity of the UV stabiliser had a substantial negative effect on retained tensile impact strength. After 3,000 hours in Borealis' WOM, ME8169 (1,500 ppm Tinuvin 783) retained approximately 82% of its initial tensile impact strength and ME8161 (1,300 ppm Tinuvin 783) retained approximately 51% of its initial tensile impact strength; and

iii) The test results for the ME8161 resin implied that after 3,000 hours in Borealis' WOM, the tensile impact strength of the resin had nearly halved.

b) *In relation to the EaB results:*

(i) No reasonable comparison can be made between the ME8152 results on the one hand, and the ME8161 and ME8169 results on the other, given that the tensile impact test results implied that the ME 8152 specimens were faulty. In any event, ME 8152 was not a tank grade. The apparently superior performance of the Borecene resins over the ME8152 ZN resin could not justify an inference that the Borecene resins were suitable for use in the manufacture of outdoor oil storage tanks.

(ii) In absolute terms, the test results for the ME8161 resin implied that after only 3,000 hours in Borealis WOM, the impact strength of the resin had more than halved.

c) *In relation to the results generally:*

i) These results related to the performance of resins after only 3000 hours in Borealis' WOM.

[37] I have omitted reference to features that Kingspan relied on which assumed that the series was based on the old UV package.

NOVEMBER 2000: BROCHURES

271. In November 2000, Borealis re-published "*Rotational Moulding*", a brochure for which Mr Webster accepted responsibility. Under the 'Applications' section, RM8402 was described as:

> *"Very good flow, combined with high stiffness. Technical and intricately shaped articles. E.g. underground, oil, water tanks."*

The brochure continued to refer to Borecene grades as "UV stabilised".

272. Borealis also re-published "*Borecene Polyethylene for Rotational Moulding*" which again indicated that Borecene had improved mechanical properties including higher impact strength and ESCR. It also stated that "*Recent developments utilising an innovative UV stabilisation system gives the Borecene grades superior light stability to standard polyethylene*."

273. Dr McDaid's evidence was that she relied on these representations:

> "*Q. Did you rely upon this document, starting on page 186, at the time at which Borecene was bought?*
>
> *A. Yes, because I[t] reiterated all of the benefits of Borecene that I and the rest of the rotomoulding industry had been advised of. It was all part of the -- it all fed into the same message."*

274. The Brochure also contained the following passage:

> *"Significant material savings*
>
> *Borecene displays improved behaviour under constant load (creep). This, together with the general improvement in mechanical properties provides the potential to significantly reduce wall thickness and so decrease the weight of most rotomoulded articles. An even wall thickness distribution due to the material's flow properties further facilitates light weighting potential."*

DECEMBER 2000: SERIES H - POLIMOON TEST RESULTS

275. On 12 December 2000, Mr Didrichsen, who has not given evidence, emailed Ms Fatnes a further set of WOM results ("WOM test 1999.xls"), which Borealis had undertaken in its WOM for a customer called Polimoon. This test, which was on ME 8169 (which became RM 8343), ME 8161 (which became RM 8403) and ME 8167, all Borecene, has given rise to considerable controversy for a number of reasons.

276. First, the results appear on a graph the title of which is "*UV testing according to ISO 8256*". That is the standard relating to testing for tensile impact strength. However the vertical axis is described as "*Elongation to break %*". There is also a reference on the spread sheet with the results to a test procedure - the use of a "*Dog bone from 1 mm compr.moulded plaques according to TC266-N200/ISO16101*". ISO 16101, although it includes an EaB test as a possible procedure, applies it to changes after exposure to

a product under evaluation, which could be the chemicals which Polimoon's manufactured tanks were meant to hold.

277. In my view the references to "*Results WOM test*" and *"Elongation to break %*" make it likely that these tests were EaB tests of a product exposed to UV in a WOM and not chemical degradation tests. I accept Mr Ervik's evidence that they were the former. The numbers are consistent with, and are expressed as, EaB percentages and not tensile impact measurements (for which the numbers are too high) in N/mm or Kj/m^2. The duration is also far greater than the 42 days required under ISO 16101.

278. Second, the results have oddities. The percentages of the original EaB were as follows:

	MFR	**1250 hours**	**5000 hours**	**7500 hours**
ME 8169/RM 8343	6	100%	92%	96%
ME 8161/RM 8403	6	99%	96%	99%
ME 8167	3.2	79%	73%	76%

Thus the value for each resin *rose* between 5,000 and 7,500 hours, although the size of the rise was very small. I do not regard this as of any significance. The difference is well within the standard deviation for tests of this kind.

279. Third, Kingspan submits that the results were inconsistent with all the previous EaB test results obtained and, in particular:

i) Series A – August 1997: The results in relation to Borecene ME8167 and ME8169 showed that the resins failed the 50% EAB test after only 2,000 hours in Borealis' WOM.

ii) Series B (the Dyno tests): The results obtained by Borealis in November 1997 and May 1998 in relation to ME8167 and ME8169 showed that the resins failed the 50% EAB test after 2,000 hours and 1,500 hours in Borealis' WOM respectively.

iii) Series C: The results obtained in July 1998 from CIBA showed that ME8168 specimens stabilised with Tinuvin 622 at a concentration of 2,500ppm failed within 5,000 hours of exposure in CIBA's WOM (equivalent to less than 4,000 hours in Borealis' WOM).

iv) Series D: The results obtained in July 1999 based on Borealis' internal testing showed that ME8161(RM 8403) stabilised with Tinuvin 622 at a concentration of 1,500 ppm retained only 61% of its initial EAB value after only 2,500 hours in Borealis' WOM. When stabilised with Tinuvin 783 at a concentration of 1,415 ppm and 2,760 ppm, the relevant percentages were 62% and 72% respectively for ME 8160 (RM 8402).

v) Series E: The results obtained in November 1999 from Cytec suggested that a Ziegler Natta grade (claimed by Borealis to be equivalent to ME8160/1) stabilised with Tinuvin 622 at a concentration of 3,000ppm failed the 50%

EAB test after only 4,000 hours in the Cytec WOM (equivalent to less than 3,000 hours in the Borealis WOM).

vi) Series F: The results obtained in December 1999 from CIBA showed that Specimen 1 (Borecene ME8168 stabilised with Tinuvin 622 at a concentration of 2,500ppm) retained only around 11% of its impact strength after 6,000 hours in the CIBA WOM, and was outperformed by Specimen 12, the ME8152 specimen with an equivalent package. There was, however, a much better result (62% at 10,000 hours) for Specimen 5.

vii) Series G: The results obtained in October 2000 suggested that ME8161/RM8403 with Tinuvin 622 at 2,500 ppm would fail the EaB test within 3,000 hours of exposure in Borealis' WOM.

280. I accept that the Polimoon results were much better than most of their predecessors. At the same time they were performed on RM 8403 with 1,300 ppm Tinuvin 783 over an extended period, and, even with a generous allowance for the deviation of results, showed *natural* Borecene RM 8403 in a very favourable light.

281. Fourth, Kingspan submits that the tests were probably carried out on Borecene resins with the old, Tinuvin 622, additive packages – hence the point at vii in the last paragraph but one. (Ms Fatnes said that the testing began in October 1999, prior to the general change in UV package to Tinuvin 783). If so, the stabilisation packages would have been:

ME8169 (RM 8343)	2,500 ppm Tinuvin 622
ME8161 (RM 8403)	1,500 ppm Tinuvin 622
ME8167	2,500 ppm Tinuvin 622

Kingspan contends that the results would not, therefore, have provided an indication of the performance of the Borecene grades in the form that they were supplied to Kingspan (i.e. with Tinuvin 783 at a concentration of 1,300ppm in the case of RM8402, and Tinuvin 783 at a concentration of 1,500ppm in the case of RM7402).

282. As to this, Mr Ervik's recollection is that the tests were carried out on the new packages and that seems to me likely to be correct. The Series H tests on ME 8169, 8161 and 8167 cannot be the tests referred to in the email of 6 November 2000 as having begun in a WOM in 5 July 1999. By October 2000 about 11,000 hours would have elapsed, not 7,500. They are, however, likely to be the tests started on 15 January 2000, including the test on ME 8169 with the new UV package in compression moulded samples referred to in that email, which as at the end of October would recently have completed 7,500 hours. If, in fact, the tests were on Borecene with the "old" package, the new package could be expected to produce even better results.

283. Fifth, the Polimoon results were based on 1mm thick compression moulded samples made from products rotomoulded by Polimoon[38], other than the ME 8169/RM 8343

[38] Borealis therefore could not have known whether any further additives were added to improve their UV/weather resistance. But there is no evidence of this and it would seem unlikely that it would have occurred without their knowledge.

which was rotomoulded by Borealis, rather than the standard 3-4 millimetre thick compression moulded samples used by CIBA.

284. On the basis of the five reasons to which I have referred Kingspan submits that the Polimoon test results could not safely be relied on as a basis for assessing the weather resistance of Borecene. Nor could they (on what was known about them in November 2000) be relied on to say that Borecene grades were UV stabilised for use in oil tanks required to withstand 10 years of outdoors exposure in Northern Europe.

2001

285. In **May 2001** further Polimoon results at 10,000 hours showed the following percentages of original EaB:

Material	Stabiliser	EaB
ME 8169 = RM 8343	1,500 ppm Tinuvin 783	70%
ME 8161 = RM 8403	1,300 ppm Tinuvin 783	83%
ME 8167	2,500 ppm Tinuvin 622	75%

It is noticeable that RM 8403 with 1,300 ppm did *better* than both 1,500 ppm Tinuvin 783 and 2,500 ppm Tinuvin 622.

286. 10,000 hours in a Borealis WOM would amount to around 800 Klys and, on Professor Malatesta's approach to about 10.6 years UK exposure, with plenty of room to go before the 50% figure was reached. These were outstanding results for ME 8161/RM 8403; and, even if the stabiliser was 1,500 Tinuvin 622, the results for 1,300 Tinuvin 783 could be expected to be as good.

2001 specification sheets

287. In **May 2001** Borealis supplied Kingspan with a specification sheet for RM 8402 which described the material as suitable for static oil tanks. It described the polymer as "*fully stabilised*" and containing a long term antioxidant. They also supplied one for RM 7402 (which has an MFR of 4) which described it as suitable for rotational moulding of products for outdoor and underground applications such as "*large, thick walled tanks*". The additive package of both was said to be specifically formulated for rotational moulding: "*the polymer is fully UV stabilised and contains long term antioxidant"*. These claims were repeated in the RM 7402 sheet of September 2001 and the RM 8402 sheet for August 2003.

APRIL / JUNE 2001: SERIES I RESULTS

288. In around **April 2001**, Borealis obtained results for the set of tests discussed between Mr Jamtvedt and Mr Vulic of Cytec in April 1999 (see para 228 above), the purpose of which had been to ascertain whether a more cost-competitive loading of Cyasorb UV-4611[39] could be used in Borecene. The Borecene used was ME 8168. The Tinuvin 783 specimens contained Tinuvin 783 at a concentration of 1,750ppm. These were compared with specimens of Cytec's UV - 3346 and UV - 4611 at the same concentration with either 2,000 or 500 ppm of zinc stearate anti-oxidant. Mr Jamtvedt

[39] Cyasorb UV-4611 was significantly more expensive than Tinuvin 783.

accepted that the 1,750ppm concentration used in these series of tests probably reflected what he would have recommended as being an appropriate starting value for Tinuvin 783 before he began the testing.

289. The first report on this project was produced on **2 April 2001** and an updated report (including results for samples exposed to 10,000 hours of Xenon Arc weathering) was produced on **28 June 2001**. The tests covered the effect of differing cycle times on the tensile strength and EAB values of the resins tested.

290. These results showed that Specimen 2, i.e. the specimen loaded with Tinuvin 783 at a concentration of 1,750ppm:

i) when processed in a 14 minute cycle, failed the EaB test after 4,000 hours in the Cytec 0.35 W/m^2 WOM, and had fallen to approximately 25% of its initial EaB value after 6,000 hours; and

ii) when processed in an 18 minute cycle, failed the EAB test after 2,000 hours, and had fallen to approximately 9% of its initial value after 4,000 hours.

Ms Fatnes accepted that these results suggested that Borecene loaded with Tinuvin 783 at a concentration of 1,750ppm was "*way off passing the OFTEC or prEN requirements of 50 per cent elongation at break*".

291. However, the tensile impact results showed a 52% and 64% retained original tensile strength at 10,000 hours.

292. Kingspan submits that all EAB results (on unpigmented Borecene) with the exception of Polimoon indicated that Borecene would be unable to withstand 22 GJ/m^2 worth of weathering or 10 years of weathering in Northern Europe. They point to Mr Jamtvedt's evidence that the poor EaB results reflected changes in the surface of the polymer, to which tensile impact tests were less sensitive.

OCTOBER/NOVEMBER 2001

Borealis proposes to sell Borecene to Kingspan

293. On **12 October 2001** Mr Wood wrote to Mr Rusk, the Operations Director of Titan, following a telephone conversation on the possibility of Borealis supplying the Kingspan Group with Borecene for the year 2002. He indicated that Borealis could consider 5 and 10K MT per annum of Borecene natural pellet, all Kingspan's needs for compounded black, and possibly oil tank green for the second half of the year. He quoted prices for the first quarter. At some stage in late 2001 Kingspan decided to use RM 8402 across the group. The decision to purchase was a commercial decision made by Mr Rusk, who acted on the recommendation of PDC who, in the person of Mr Gregg, felt able to recommend it because (a) it had been said by Borealis to be suitable for oil storage tanks; (b) Borecene had been passed by Athlone; (c) Borealis had provided a certificate of conformity; and (d) Dr McDaid had carried out trials. It began to be delivered in production volumes in early 2002.

KIWA

294. KIWA is the approval/certification body for the Netherlands. In 2001 Kingspan was exploring the possibility of entering the market for oil tanks in the Netherlands. It was, therefore, concerned to involve itself with the content of the standards to be applied by KIWA. KIWA had asked for information on the weathering /UV performance of Borecene for 10-25 years.

295. On **13 November 2001**, Dr McDaid emailed Ms Fatnes:

> "*We are currently looking at supplying a number of Kingspan rotationally moulded products into a new market. One area that we are being asked to supply information on is the weathering/UV performance of the product* ***for 10 and up to 25 years.*** *Borealis supplied us with a letter of conformity for the purpose of gaining OFTEC material approval (8402) which stated that the grade met the requirements of the weathering test in OFS T100. Do you have any information/test results you could share with us on the long-term weathering properties of RM grades, both natural and pigmented*" [Bold added]

This was the first time that Kingspan had asked for UV weathering data.

296. On **18 November 2001** Ms Fatnes replied:

> *"We have been struggling a lot with our Weather-O-Meters and UV testing in general for a long time. So the amount of documentation is not on the level we would like to see it.*
>
> *In general my recommendation would be:*
>
> - *for UV exposed products with expected lifetime of five years - Natural Borecene can be used*
> - *for lifetime 10 years - Colours improving UV performance are needed, (example green for OFTEC approved tanks)*
> - *for lifetimes > 10 years: Black Borecene grades are recommended.*
>
> *The OFTEC statement was given before a lot of data was available, on the following bases:*
>
> - *ME8152*[40] *was already approved*
> - *The RM8402 UV package was improved to double the lifetime of the Borecene grades vs. ME8152*
> - *The green pigment would bring the necessary additional UV performance.*
>
> *Since Borecene has a much higher starting value for Elongation to break, the traditional measurement of defining lifetime as the time when 50% reduction*

[40] Borealis' general purpose ZN product.

of elongation to break is reached, is also negative for Borecene vs. materials starting at a lower elongation to break. So we have also tried to look at lifetime based on impact performance.

Please find below some slides showing UV test results for Borecene"

297. At some stage Dr McDaid wrote in manuscript on the email "*5 yrs N European*" and "*Change OFTEC letter of conformity to 34 GJ/m²"*. As is apparent from the note, by this time she had become aware of the miscalculation in converting 900 Klys.

298. Dr McDaid said of this email:

> *"......To me that was confirmation that the green pigment, as used – the green colour, let's call it phthalocyanine green, used by Kingspan and all of the other -- the vast majority of the other tank manufacturers would provide ten years' UV performance."*

299. Of the statement that *"The RM8402 UV package was improved to double the lifetime of the Borecene grades vs. ME8152"* she said that it :

> *"....confirmed to me that the conventional grade, the ME8152, which had been already OFTEC approved, and I was aware had been supplied to the industry for many years, that the UV performance – that the UV package in that had been improved, as it says, to double the lifetime in the Borecene RM8402 grade."*

300. The email was accompanied by eight slides. The second slide said this:

BOREALIS_

Exposure in WOM – what does it mean

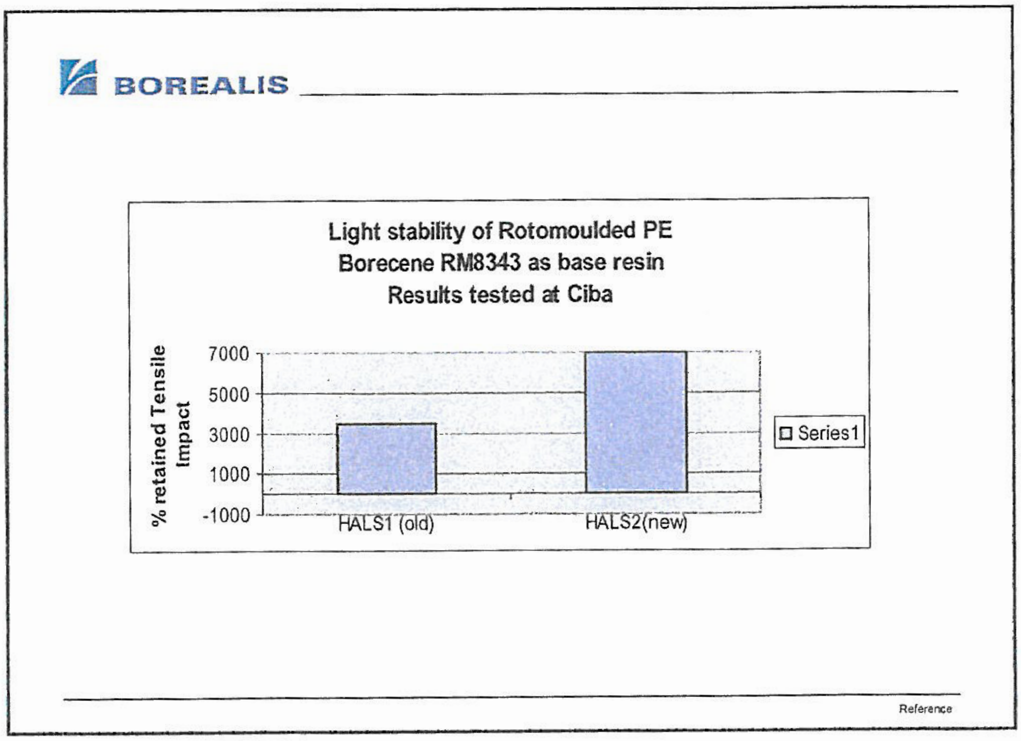
- *Exposure time in WOM* — *4000 hours (UV2)*
- *Equivalent UV exposure* — *250 Kly*[41]
- *Estimated lifetime Scandinavia* — *4 years*
- *Estimated lifetime South Europe* — *2 year*
- *Estimated lifetime Florida* — *2 year*
- *Estimated lifetime Southern Canada* — *3 years*

- *Estimated lifetime is based on the exposure time in WOM when mechanical properties have been reduced to 50%*

301. It is not wholly clear where the data in this slide came from. But it looks as if it was from the toolbox or from whatever it was that caused the entries in the toolbox: see para 260 above.

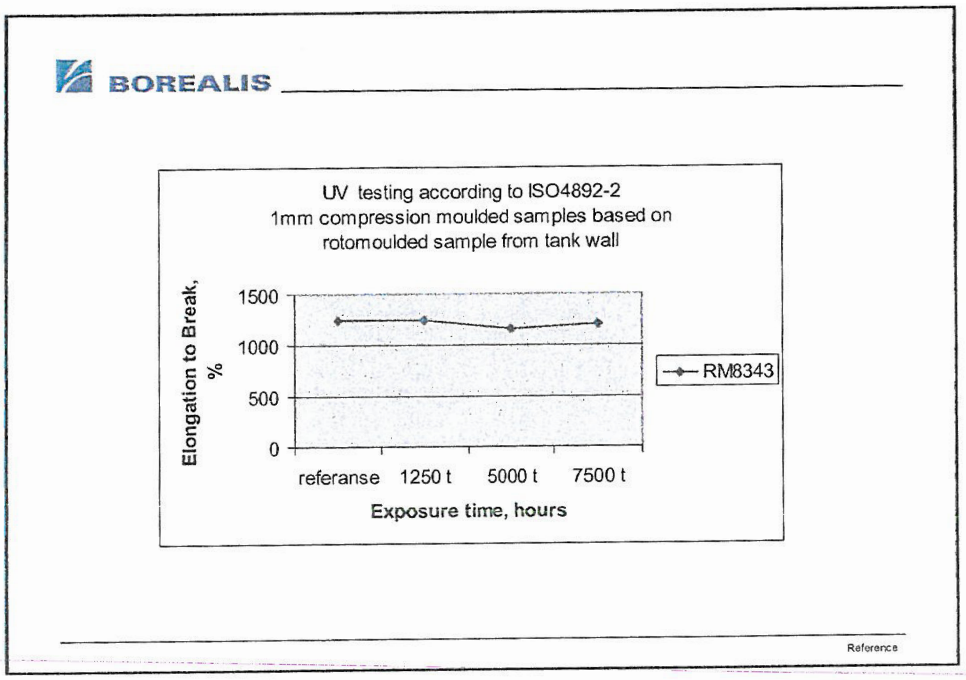
[41] This calculation is broadly correct for a WOM of 0.35 W/m². But it is not correct for a 0.51 W/m² WOM for which the figure is about 300 -350 Kly equivalent to about 4 years at 80 Kly per year. Series A, B, D, G and Series H were carried out on a Borealis' WOM of 0.51 W/m².

302. The fourth slide looked like this:



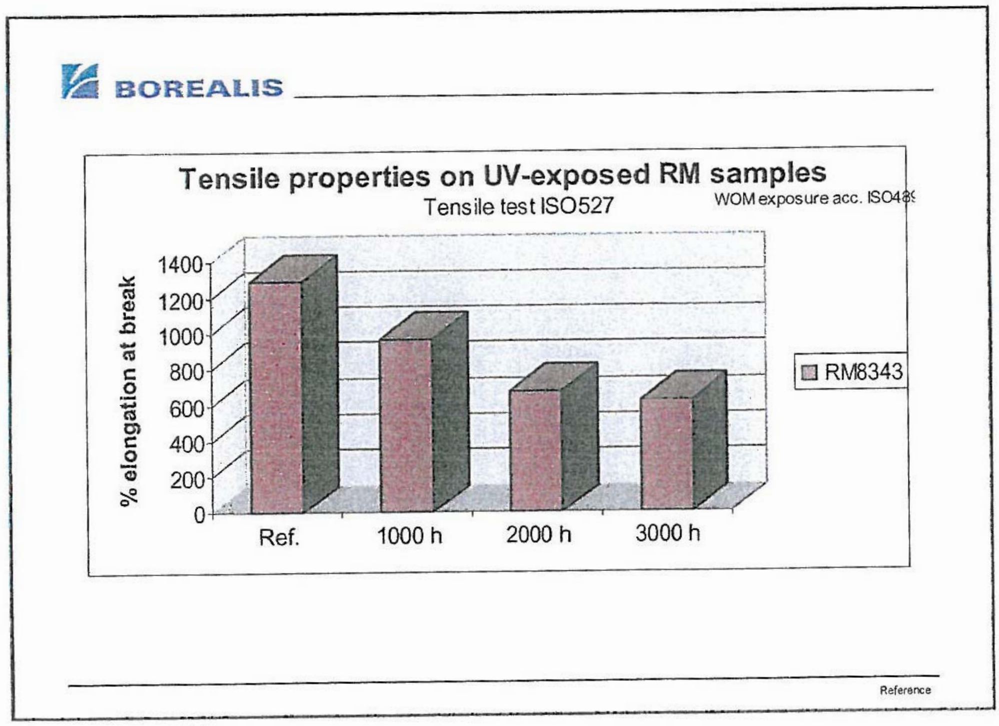
303. This graph was based on the Series C CIBA test results of July 1998 and compared Specimen B (Borecene ME 8168 Tinuvin 622 2,500 ppm), on the left hand side against the results for Specimen I (ME 8168 Tinuvin 783 2,500 ppm), on the right. The vertical axis is the hours of exposure necessary to produce 50% of the original tensile impact strength. But the Specimen B result was suspect: see para 210 above.

304. The fifth slide looked like this:

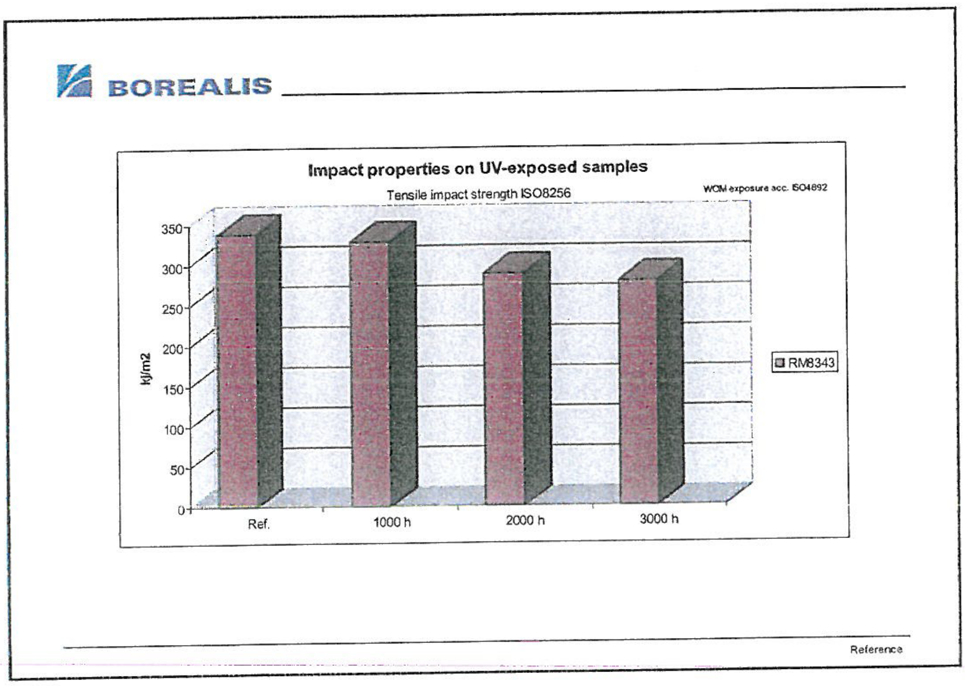


305. These were the Polimoon results from Series H (excluding the 10,000 hour result) for RM 8343 (=ME 8169) – the results for RM 8403 were in fact better. They indicated that EaB remained close to the original figure and at about 95% even at 7,500 hours.

306. The sixth slide looked like this and contained data in relation to EaB properties :



307. The seventh slide looked like this and contained data in relation to tensile impact strength:



308. These data were in each case derived from the Series G results for ME 8169 (RM 8343) which were more favourable than the ME 8161 (RM 8403) test, even though ME 8161 was the powder form of 8402 which Kingspan was about to purchase in large quantities.

309. The eighth slide said this:

> ***BOREALIS_***
>
> ***BORECENE – UV performance***
>
> *Based on previous test data it can be concluded*
>
> - *Expected lifetime for Borecene (time in WOM till 50% retention of properties):*
>
> - *Based on Tensile Impact evaluation (extrapolated) 6000 hours **
> - *Based on Elongation to break 4000 hours **

310. A number of other things were apparent from this email. Firstly, the recommendation for 10 years was given on the footing that the green pigment selected would double the weatherability and 10 years would be the limit beyond which black was recommended. Second, Borealis expressed themselves as having been struggling with their WOMs and UV testing for a long time with documentation not on the level they would like to see. That was an indication that Borealis did not have a sizeable body of recorded data bearing on the question of weatherability and was given on the basis of limited information. Third, the WOM EaB results on natural Borecene were expressed as giving a lifetime of 4,000 hours representing 250 Kly (erroneously as it happens – the correct figure beings about 300 – 350 Kly). The WOM tensile impact results were expressed as giving a lifetime of 6,000 hours which in a Borealis WOM would be something like 500 Klys. 22 GJ/m^2 is about 500 Klys. 34 GJ/m^2 is about 800 Klys. This figures show the effect which the pigment would need to have depending on the figure for natural Borecene from which you start and the Kly figure which you wish to replicate in a WOM.

Embedded data

311. The data slides in the PowerPoint file from which the slides emanate contained embedded data, of which Ms Fatnes was unaware, but which Kingspan was able to access by double clicking on the top slides. I regard the significance of that as very limited. The necessarily complicated analysis of the point is contained in **Appendix 4.**

Dr McDaid replies

312. Dr McDaid replied to Ms Fatnes the next day. In her email she said:

> *"Have Borealis ever tested pigmented samples similar to the 'tank green'?*

I am not sure if are [sic] aware but there was an error in the weathering test requirements in OFS T100 and prEN13341. The irradiance was miscalculated as 22 GJ/m2 instead of 34GJ/m2 (equivalent to 800 Kly). In the letter of conformity received 16/08/99 from Leif Rhen [sic] the weather resistance of ME8161[42] is given as 'exceeding 22 GJ/m2'.
Can you please re-issue the letter of conformity for RM8402 stating that the weather resistance will exceed 34 GJ/m2 (elongation at break shall be greater than 50% of the initial value)."

313. On 26 November 2001, Ms Fatnes responded in the following terms:

"We have tested several coloured samples, but have not tested "tank green" as far as I know. We would be very interested in getting relevant sample (or the pigment) for testing.

Regarding OFTEC:

I knew the CEN standard was updated but was not aware of the change in OFTEC. Could you get me a copy of the latest version?

We will of course **look into updating the statement** *according to the latest OFTEC requirements. To whom should such a statement be sent."* [Bold added]

314. On the evidence before me it is true that Borealis had not tested tank green so far as any tests on ME 8160/1 = RM 8402/3 are concerned. But Ms Fatnes appears to have been unaware of, or forgotten, the Dyno tests which did include Green Borecene ME 8169.

315. Kingspan submits that the absence of any suggestion that Borealis needed to conduct further tests before issuing an updated letter of conformity implied that Borealis was satisfied that Borecene was capable of withstanding 34 GJ/m^2 of weathering (circa 800 Klys). I do not, however, regard this email as making any statement about compliance with any 34 GJ/m^2 standard. Borealis simply said that they would look into the question of updating the letter. Moreover the figures given in the second and eighth slides attached to the email of 18 November would not necessarily be ones on the basis of which Borealis would express an expectation of 34 GJ/m^2.

316. There is no evidence that any version of the OFTEC Standard was sent in response to the email of 26 November.

Borealis' concerns over the cost of UV stabiliser

317. Borealis was now acutely aware that its products were more expensive than those of its competitors. A Borealis presentation document of 19/20 November 2001 referred to the price pressure from its competition:

"Market Situation

[42] In fact the letter relates to the moulded tank.

- Market price remains well below Borealis prices:

- *Bonar buying DOW @ є760 nat.pellets*
- *ICO switching volume to Exxon at є750/t*
- *Borealis = є850/t lowest"*

318. On **26 November 2001** there was an internal meeting of the Customer Support Team ("CST") at Borealis. The minutes record that the focus for 2002 was to include a reduction in additive cost by 10% in Borecene RM. The minutes of a further meeting on 11 March 2002 record that "*New UV and at lower concentration for Borecene RM will be tested in March*".

2002

319. The **19/20 November 2001** presentation document also recorded:

"*Lowlights:*

- *Big problems with cracking oil tanks at Balmoral – polymer or pigments".*

320. On **4 January 2002** Mr Wood sent an internal email which said:

"Finally we received an order for 3000 Mt of RM8402… In the knowledge of Balmoral's problems should we consider introducing RM 7402 for Oil Tanks – if there is a problem it would be multiplied 6 fold!!!"

Correspondence about the KIWA standard

321. At the turn of the year Dr McDaid and Ms Fatnes were in correspondence about the latest draft of prEN13341 and how the proposed KIWA standard might differ from it. Borealis was trying to help Kingspan in their discussions/negotiations with KIWA, which was showing signs of wanting to set a national standard of its own, despite the proposed European one. On 6 December 2001 Dr McDaid sent Ms Fatnes the latest draft of prEN13341, which she asked to be kept confidential, together with extracts from the proposed Dutch standard. She pointed out that KIWA wanted to test for UV stability over a shorter period than the European standard i.e. for the equivalent of 5 years exposure in a moderate climate and that KIWA also insisted that tensile impact was a superior test for detecting surface degradation. She also said that moulded samples of pigmented (tank green) RM 8402 and a powder sample would be shipped to Borealis that day.

322. On **18 December 2001**, after these had arrived, Ms Fatnes asked to know what the pigment was and who was the pigment supplier. Dr McDaid replied saying that Kingspan did not tend to disclose their pigment supplier but that she would try to obtain any information particularly required from them directly. In her reply Ms Fatnes said, inter alia, that the pigment type was essential for understanding its effect on the UV performance. Dr McDaid agreed to get the information sought.

323. On **8 January 2002** Dr McDaid supplied an "H & S Data Sheet" for the Oil Tank Green pigment. On 14 January 2002 Ms Fatnes responded to a question that Dr McDaid had asked as to whether she expected pigmented RM 8402 to meet a particular requirement of KIWA (that after the equivalent of 5 years' exposure the change in tensile impact strength should not be greater than 25%) by saying that she would like to see some results from the UV test on the green samples that Kingspan had sent for testing before replying.

324. On **28 January 2002** Ms Fatnes sent an email to Dr McDaid in which she said:

> *"2) Regarding the UV requirements in prEN 13341 (total irradiance of 34 GJ/m² there may be something wrong. I just got a big ? from my colleagues who are experts in this field. 34 GJ/m² may be far too high. We are checking this via other experts in the field..*
>
> *Please let me know what* ***expected lifetime for outdoor tanks would be (I have been assuming 8-10 years mid European climate****. Is that correct?)"* [Bold added]

325. This email is somewhat surprising given that Ms Fatnes was present at the OFTEC meeting of 15 September 1999 at which it was agreed that the correct measurement should be 37.5 GJ/m² as the equivalent to the 900 Klys specified in both the Standard and prEN13341. In any event on 28 January Dr McDaid emailed to say that she understood that 34 GJ/m² was based on an assumed 10 year Northern European exposure. On 5 February 2002 Ms Fatnes emailed Dr McDaid to say that Borealis had looked into "*the UV requirement "34 GJ/m²" and I can confirm that it is in principle OK and corresponds to 10 years North European climate*".

326. I do not regard this email, which was not sent with any intention of inducing Kingspan to buy Borecene, as making any statement about whether RM 8402 satisfied the prEN13341 requirement to have an EaB of more than 50% after irradiance of 34 GJ/m² in a WOM. It is the end of a discussion, itself part of a discussion about the draft European standard and the proposed KIWA standard and the differences between them, of what 34 GJ/m² represents in terms of exposure in Northern Europe.

327. On **6 March 2002** Mr Ervik wrote to Dr McDaid (further to her request of 22 January 2002) stating that "*optimum peak temperature for Borecene RM8345 (powder version of Borecene RM8344) is approx 190°C, when using a rotolog. Borecene RM8345 may however be processed at 190° C + / - 20 C and still have satisfactory properties.*" RM 8345 had an MFI of 6. Mr Halvorsen subsequently sent Dr McDaid a memo on 16 April 2002 saying that Borecene (he was referring to Borecenes generally) could be processed at a peak temperature of 175°C, and then later on stated that it could also be processed at a peak temperature of 220°C "*keeping good mechanical properties*". These two temperatures produce a PIAT window of 45°C. The memo said that Borecene has a broader processing window temperature wise than conventional materials.

2002 Orders

328. Until about the end of October 2002 Kingspan ordered RM 8402 from Borealis and it was used in all four factories.

August: internal Kingspan correspondence on UV stabilisers

329. On **27 August 2002**, Mr Gregg of PDC, prompted by what was then thought to be the impending introduction of prEN13341, sent Mr Phelan, Mr Fred Rusk and Dr McDaid an email with an attachment setting out his understanding as to the relationship between UV packages and what was required to provide 10 years of weather resistance in Europe. The attachment stated:

> *"Titan have always specified UV8 package or equivalent to provide sufficient UV protection for minimum 10 year life in Europe (incl S Europe).*
>
> *EN 13341 specifies that the material must be tested to a total irradiance of 34 GJ/m², which is the equivalent of 10 years exposure in Northern Europe.*
>
> *It has been brought to our attention that some suppliers are not using a UV 8 package. This is being further investigated through our contacts and more information should be available in a week's time.*
>
> *As it stands we know that material supplied with the UV8 package in the past has provided us with a minimum 10-year life span in the UK and hopefully on the continent.*
>
> *To date we have not had to conduct any weather resistance tests* ***and have been able to get by*** *with a certificate from the material supplier.*
>
> *We have concerns that unless we have a UV8 package there is a strong possibility that the material will not pass the EN weathering test. In fact some material suppliers have also expressed reservations.*
>
> *We strongly recommend that each material supplier be reminded that all future supplies are to a minimum of UV8 specification, if not we will remove them from our preferred suppliers list"* [Bold added]

330. The attachment went on to express concern about the extent of the programme of tests on materials which the EN standard would require manufacturers to carry out.

331. It is apparent from this email that Kingspan was working on the basis (a) that a 10 year minimum lifetime was needed for prEN13341; (b) that material to the UV 8 standard would provide it (in fact it could only do so with pigment); and (c) that it had been possible for them to "*get by*" by way of compliance with section 4.1 of the OFTEC standard by relying on a raw material manufacturer's certificate of conformity.

The involvement of Mr Shorter

332. By 2002 Mr Shorter had left Borealis and had set up ECMS, a consultancy firm in rotomoulding. He is the contact, or one of the contacts, referred to in the 27 August email. In late August 2002 Mr Gregg engaged him to test the materials supplied by different suppliers to Kingspan to determine the UV additives/absorbers used by them. On 2 September 2002 Mr Shorter emailed Mr Gregg to confirm the upshot of a telephone conversation between them that day, namely that Mr Gregg would forward

samples to be tested for UV additive package and Mr Shorter would prepare a technical report comparing their performance with that of a typical UV package. Mr Shorter suggested that the timing was right for a company like Kingspan actively to specify to their supplier what performance was required in terms of UV resistance. Before then Mr Gregg had seen no such need, taking it for granted that suppliers providing raw materials to manufacturers would ensure that the material met the weathering requirements of the OFTEC Standard.

333. In the course of this conversation Mr Shorter had indicated, inter alia, that some suppliers had been downgrading their UV package over the last 12 – 18 months; that he had done a lot of the earlier work for OFTEC and, although no weathering tests were carried out he would be fairly confident that a material with a UV 8 package would pass the new European weathering test but he was doubtful whether a UV 6 material would do so.

SEPTEMBER- OCTOBER 2002: BOREALIS' CONCERNS OVER CRACKING TANKS

334. On **6 September 2002**, Ms Fatnes wrote to Mr Ari Makela (of Borealis) indicating, in relation to Balmoral, that she had got indications from Mr Halvorsen that Borealis "*may have a big problem here*". The same day, Mr Halvorsen also wrote to Mr Makela providing an update on what had been done as a result of Balmoral's problems with Borecene. He indicated that, in the light of Balmoral's problems with cracking tanks, Borealis undertook a range of testing on RM8402, RM7402 and a reference grade. Based on the outcome of the testing they could not find any problems with the material.

335. Mr Halvorsen said:

> *"Therefore internally we have discussed [the Balmoral issues], and we have decided to do some more testing. The reason for this is that maybe UV stability is influenced. Just to try to explain you, when you do a tecroblend[43], all natural particles will not be coated with pigment – compare to what will happen with a dry mix. Therefore we want to test elongation to break after the samples have been exposed in Weather-O-Meter. I doubt this is the case but still I think we should do the testing. The customer is not informed about this*
>
> *Based on all this, I believe the way of processing is the problem …"*

336. Ms Fatnes was not able to say whether any further EaB or other weathering tests were undertaken on samples exposed in a WOM. Nor could Mr Halvorsen recall whether any weathering tests had been done as part of the Balmoral investigation, but he thought that some FTIR tests may have been done under Mr Borve's auspices. Borealis considered that the cause of the problem might be that Balmoral's pigment was not covering all of the material. If that was true, then the natural material left uncovered by pigment might be degraded by UV. In the event Balmoral's tanks proved not to have been degraded.

337. In **October 2002** Borealis produced an internal presentation in relation to the tank failures at Balmoral. One of the questions asked was:

[43] 25% compound mixed with 75% natural

"UV is the amount we add sufficient for 10 years outside in Europe?

Check with additive group + supplier (statement)". [Bold added]

Mr Borve of Borealis was to address that question and tests were to be carried out on RM7402/RM8402 using "*Maus mould with small radius*" with various different green pigments, different coating levels, and with dry-blended and grind blended material.

338. One of the slides for the presentation set out the advice of Dr Astrid Frøhaug, a member of Borealis' Additive Research department, as contained in an email of **4 October 2002.** The email and slide stated:

"10 years outdoor in central Europe corresponds to 15,000 hr in weather-o-meter (WOM)[44]*.*

We have some data for natural nonpigmented Borecene. We have 65% retained tensile strength after 10,000 hr in WOM with 1750ppm Tinuvin 783[45] *(about 6.5 year) (But you may have other results if you are measuring other mechanical properties...,and it is also a matter whether you are measuring absolute or % retained strength). We have a lot of data showing that we have the same UV-stability with the new recipe as with the old one.*

Nearly all pigments has a positive effect on the effect on the UV-stability (except azo red and yellow). Ti02 (white) is the poorest one, only doubling the UV-stability while e.g. phthalo green is about 5x better than unpigmented PE. So with "normal" amounts of UV-stabiliser and a "normal" pigment it should be no problem to stand 10 years outdoor in central Europe…"

339. Kingspan observed that it is apparent from this passage that contrary to what Borealis had told Dr McDaid on 18 November 2001), Borealis (or Dr Frøhaug at least), recognised that the new Tinuvin package did not give rise to a doubling of the lifetime of Borecene as against ME8152. It is not clear what was the basis upon which the observation "*phthalo green is about 5x better than unpigmented PE" was made.* It may be that Borealis tested some green pigmented Borecene samples; but, if so, such tests have not been disclosed.

SEPTEMBER/OCTOBER 2002: THE BALMORAL PROBLEM WORSENS

340. By now Borealis had come to realise that the Balmoral complaint was a potential time bomb insofar as RM 8402 had been sold to other customers with similar applications.

341. On **25 September 2002** Mr Borve wrote to Mr Webster with the results of tests undertaken to ascertain the concentration of UV stabiliser contained in a specimen of Borecene sent to Borealis by Balmoral for testing. Mr Borve indicated that:

"*the conclusion from the analysis of the powder-sample showed that both polymers were of RM8402-type, and contained around 1800 ppm UV stabiliser (normal)".*

[44] This figure is not correct for a Borealis WOM.
[45] This refers to the Cytec tests – Series I.

Kingspan observe that, if 1,800 ppm was to be regarded as a 'normal' concentration of UV stabiliser in September 2002, it is unclear how Borealis could have justified its previous decision to reduce the stabilisation in RM8402 to 1,300ppm. I am not convinced that much can be read into this. Mr Borve may simply have been indicating that 1,800ppm was not abnormally low. Stabiliser concentrations have a target and a max/min figure. The range from min to max may be 4-500 ppm. Borealis aimed always to be above the target. In those circumstances 1,800 ppm could be regarded as not abnormal if the target was 1,300 ppm, even though it is 500ppm in excess. It is also not clear what the stabiliser was.

342. In his reply of the same day Mr Webster said that Mr Joyce of Balmoral had been on the telephone and that Mr Webster had told him that one of the six matters that Borealis were looking at was whether the amount of UV added was "*sufficient for 10 years outside in Europe*." Mr Webster's evidence was that Mr Joyce had asked that question. In the event, in October a programme of investigation was worked on between Balmoral (Mr Joyce) and Borealis (Mr Webster and Mr Borve) at an ARM conference in Toronto. Balmoral tanks were failing in substantial numbers after a relatively short time, such that inadequate UV resistance could not be the cause. On that account Borealis decided not to make UV a central feature of their investigation.

Series J The KIWA tests

343. Borealis undertook testing on four differently processed specimens of the materials used by Kingspan to make its RM8402 tanks. The testing was carried out in respect of each specimen type at two different testing speeds (100mm/min and 50 mm/min) in the Borealis WOM. The parties are agreed that the specimens tested were as follows:

a) A - Flat sections cut from a cube shaped product **rotomoulded** from **green** dry blended powder in a trial **by PDC**. The test specimens were machined by Borealis directly from these sections. Sections and specimens were **3.5mm** in thickness

b) B - Flat sections cut from a cube shaped product **rotomoulded** in a trial by PDC, and then **compression moulded** by Borealis to a 1mm thickness in order to comply with the UV test methodology in **preEN13341** and **KIWA**. The test specimens were machined by Borealis from these 1mm sections.

c) C - Flat sections cut from a cube shaped product, **rotomoulded by Borealis** from **green dry blended powder** supplied by PDC. The test specimens were machined by Borealis from these sections. The specimen thickness was 3.5mm.

d) D - Samples compression moulded to 1mm thickness by Borealis **directly from green powder supplied by PDC** (and **not at any stage rotomoulded** in the course of the samples' preparation). The test specimens were machined by Borealis from these 1mm sections.

No testing was done of similar samples with other materials.

The results

344. The results of these tests, available in September 2002, were concerning in that at 4,000 hours in a Borealis WOM the A specimens, sections from Borecene rotomoulded by PDC from green dry blended powder, had failed, having either 34% or 42% of original EaB. At the same time Sample B had either 69% or 60% of original EaB; Sample C had 52% or 66% and Sample D had 62% at 100mm/min.

345. Sample B, which had not failed at 4,000 hours would have had (on a linear extrapolation) an expected lifetime of between 6,000 and 7,000 hours which would probably meet the 22 GJ/m^2 requirement and give a UV-X rating of between UV 8 and 10. But there was no room for improvement on account of pigmentation since these tests were on pigmented material.

346. As appears from paragraph 73 above, tests of 1mm compression moulded samples of Dow NG 2432 carried out in 2005 by RAPRA produced significantly worse results, in that failure occurred after 3,000 hours in a 0.51 W/m^2.

Borealis stops deliveries of RM 8402

347. On **23 October 2002** Mr Wood stopped all deliveries of RM 8402 to Kingspan. In an internal Borealis email of that date Ms Bergius said that this was:

> *"..due to fear of problems with the tanks after production/use ref problems/big claim from Balmoral*
>
> *Bob asks that RM 8402 be changed to RM 7402 for these customers"*

348. The evidence as to exactly why Borealis took this step is unclear. Mr Webster said that it was very much Mr Wood's suggestion. Kingspan had some concerns and wanted reassurance so he thought - why not take a belt and braces approach? Mr Wood said that the initiative for a change came from Mr Rusk, who was concerned about RM 8402. He, Mr Wood, thought that, if Mr Rusk was concerned about the RM 8402, then RM 7402, with a slightly lower MFR (UV was not then in issue), would be slightly tougher and so why not go for that? He claimed not to have been influenced at all by the KIWA results (which he could not recall whether he had received). The change was just to give the customer a feeling of confidence.

349. The likelihood is that Mr Wood had by the end of October already learnt of the KIWA test results[46], which – on the assumption that you could treat reaching 50% of the original EaB as the time when UV related cracking would occur - showed, so far as the A specimens were concerned, that, even with the green pigment chosen the material would not last 10 years nor even withstand 22 GJ/m² and would, in any event, fail the OFTEC and prEN13341 EaB tests. In the light of that, as Ms Bergius' contemporaneous email shows, he feared that continued use of RM 8402 might lead to a claim of similar magnitude to that being presented by Balmoral and, therefore, asked for the change to be made.

Reporting to Kingspan

[46] The results had been obtained by no later than 13 September – see Dr McDaid's email to Ms Fatnes of that date. Ms Fatnes was sent them by a Borealis lab technician on 26 September 2002.

350. The first version of Borealis' report on testing RM 8402 for KIWA approval is dated 7 October 2002 and was sent to Dr McDaid by Mr Halvorsen on 8 October 2002. It contained no reference to any UV results. The second version of the report, which was sent to Dr McDaid by Mr Halvorsen on 1 November 2002, gave the result for sample B - the specimen type defined in the prEN standard. This revealed that after 4,000 hours the sample had decreased from 1,200 % to 820 %, the latter figure being c 68% of the former. No other results were included.

The 16 October 2002 telephone conversation

351. Meanwhile on **16 October 2002** Dr McDaid had had a conversation with Mr Halvorsen. He told her that the rotationally moulded A specimens had failed before 4,000 hours. Dr McDaid then had a conversation with Ms Fatnes in the course of which she was given details of the 4 sample results. For some reason Dr McDaid made two notes of this conversation.

352. According to one of them Ms Fatnes said (a) that the Borealis package was UV 5 or 6 and that Borealis had never claimed to use a UV 8 package; and (b) that she was aware of the UV requirement of prEN13341 and the OFTEC Standard but was not concerned and thought that the pigment would offer sufficient protection over 10,000 hours. She said that the 10,000 hour requirement of prEN13341 – the EaB test - put Borealis at a disadvantage because, even with a 50% drop the absolute value was much higher than that of competitors at the 50% stage - the EaB test disadvantage point. According to the second note she was *"confident"* that the green pigment would extend the range sufficiently to meet the European standard.

353. Ms Fatnes' evidence is that, while she may have said that she expected pigments to extend the lifetime of Borecene, she thought it unlikely that she would have assured Dr McDaid that the addition of green pigment would extend UV performance of the end product sufficiently to meet the requirements of prEN13341 or OFTEC because the lifetime of a product depended on a number of factors such as pigment and processing over which Borealis had no control. It was, she suggests, unlikely that she would have given such an assurance during a conversation about the KIWA results, which were themselves obtained from green pigmented samples from Kingspan which showed, in respect of Sample A, the opposite.

354. I think the likelihood is that Ms Fatnes, whilst giving no assurance, said that she confidently expected that *an appropriate pigment would* extend the UV weatherability for the requisite period.

355. It is not suggested that Kingspan was induced to continue purchasing Borecene, whether RM 8402 or RM 7402, as a result of what was said in this telephone conversation. Dr McDaid discussed this conversation with Mr Gregg. His evidence was that he was shocked because he thought that it was for the material supplier to ensure that the material supplied would, of itself, i.e. without pigment, satisfy the OFTEC UV requirements.

356. On **17** and **24 October 2002** Dr McDaid and Mr Gregg spoke with Mick Shorter. Her note of these conversations, which accorded with Mr Gregg's general recollection, reads as follows:

> *"**Borealis – UV Package, discussion with Mick Shorter, 17/10/02 & 24/10/02***
>
> *Borecene grades were specified with a UV 8 package in their early days. MS had a signed agreement with Borealis that they would not alter the package without consulting him.*
>
> *In Dec '00 he visited Norway and was informed that the package had been reduced to UV 5 in Jan '00.*
>
> *MS indicated that it would take up to 5 years to effectively approved (sic) a UV package.*
>
> *He suggested that the switch was made for processing efficiency and cost savings. Suppliers are keen to harmonise packages in various grades for different processes/applications."*

Complaint and response

Mr Rusk's letter of 30 October 2002

357. In the light of what they had learnt from Mr Shorter Dr McDaid and Mr Gregg drafted a letter for Mr Rusk to send to Mr Wood of Borealis. This letter was sent on **30 October 2002**. In it Mr Rusk referred to the "*alarming*" UV test results for RM 8402 samples. He observed that the specimen type defined in prEN13341 (i.e. Sample B) was expected to reach the limiting value of 50% at less than 7,000 hours rather than the 10,000 hours required by that standard[47]. He referred to Miss Fatnes' telephone conversation with Dr McDaid of 16 October 2002 (see para 351 above); pointed out that the UV 5 package to which she had referred offered substantially lower UV protection than what he described as the industry benchmark[48] of a UV 8 or equivalent package; and said that Kingspan had always been assured by Borealis that their grades approved for tank use would meet the requirement of the OFTEC and prEN standards, but the test results clearly indicated that RM 8402 would not pass the UV test in the prEN standard and would not therefore be suitable for use in oil tanks and also, he said, invalidated the OFTEC approval for RM 8402.

358. The letter went on to say:

> "*We would like to draw your attention to three other relevant items of information with (sic) are very pertinent. Firstly, when Borealis first approached Tyrrel/Plashapes in the early 1990's with the intention of selling them material they were advised that amongst other properties the minimum UV performance would have to be based on Du Pont 8504 UV8D which we were using at that time, (see attached specification sheet). Secondly, trials were conducted at Tyrrel Tanks in 1996 and 1997 when the subject of the UV package was discussed. On both occasions Borealis confirmed the use of a*

[47] That this was Kingspan's extrapolation from Sample B appears from one of the slides for the 3 December 2002 meeting: S 14/19 – see para 371 below.
[48] Dr McDaid accepted in evidence that there was no such benchmark. Different suppliers used different benchmarks.

UV 8 package. Thirdly, in a recent meeting with Fred Rusk at Titan Environmental Bob Wood and John Webster when asked about the UV package in RM8402, claimed it was UV8."

All future orders were to be placed on hold until a satisfactory response to the concerns expressed in the letter.

Mr Shorter's report of 31 October 2002

359. On **31 October 2002** Mick Shorter sent his report on additives. This revealed that the Borealis sample which he had had analysed had a UV stabilisation package of 700 ppm Tinuvin 622 which Mr Shorter described as on the low side of a UV 4 level of performance. He observed that a UV 8 level would be achieved by a typical formulation based on, e.g., 2,000 ppm of Tinuvin 783 and a UV 4 performance would result from using 800-1,000 ppm. He expressed the view that the level analysed in the Borecene sample indicated a performance below UV 4.

The meeting of 1 November 2002

360. A meeting was arranged for **1 November 2002** at the Banbridge site to discuss Mr Shorter's conclusions. It was attended by Mr Shorter and Noel Crowe, Pat Phelan, David Drury, Dr McDaid, Mr Gregg and Fred Rusk of Kingspan. Dr McDaid and Mr Gregg expressed dismay that Borealis had let them down in that PDC had proceeded on the basis that the Borecene grades met the relevant OFTEC standards but in the light of Ms Fatnes' statements and Mr Shorter's investigations it was apparent that they did not or at least there was evidence that they did not. The upshot was that PDC was to pursue investigations with Mr Shorter.

361. On 7 November Dr McDaid gave instructions to Mr Shorter to do the following:

> *1. Identify appropriate and compatible anti-oxidant and UV stabilisers packages, types and % addition/ppm suitable for 'tank' grades.*
>
> *(Typically 938-940kg/m3 & 2-6 MFI). Provide a comparison of loading versus UV5, UV8 etc.*
>
> *2. Above packages to be specified for dry blended products required to meet a) prEN13341, and b) conditions in Southern Europe (mostly Spain and Portugal).*
>
> *This information will enable us to be more specific with suppliers and also, measure current packages against our requirements.*
>
> *3. Identify two suppliers of virgin 'tank' grades without any additives and cost appropriate packages to meet requirements above in 2."*

362. As is apparent from these instructions Kingspan had not previously specified an anti-oxidant or stabiliser package to their suppliers. Mr Gregg had assumed that all the

material Kingspan purchased met prEN13341 and that no additive package needed to be specified.

Ms Fatnes' reply of 14 November

363. Ms Fatnes replied to Mr Rusk's letter on **14 November**. She said that "UV testing" and "UV performance" were not easy and straightforward tests; that a number of factors influenced the results such as the material and its stabilisers, the preparation of the test piece (compression moulding, rotational moulding etc.), the preparation of the dogbone for the test, the WOM used, the temperature and humidity in the test chamber, and the tests used (EaB, tensile strength, tensile impact etc.). As a result of becoming increasingly aware of this Borealis had tried to reduce the variation in the test results and to understand the different factors; and had chosen to rely a lot on advice and test results from additive suppliers. Based on that information the UV package chosen "*was expected to meet the requirements to UV performance*". Internal tests at Borealis had not been able to fully show this and "*therefore we have done work to clarify the reasons behind*". (This was a reference to data from CIBA and Cytec).

364. Ms Fatnes made the EaB test disadvantage point and suggested the comparison should be between remaining properties and not a 50% reduction from highly variable starting levels. (The problem with that point is that the material, when moulded, needs to pass the EaB test in order to comply with the OFTEC Standard, and would need to do so in the future to comply with the prEN standard).

365. She explained that the letter of conformity had been made "*to the best of our knowledge and on the following arguments in lack of real data*": ME 8152 (which was the general purpose ZN) had been used earlier and conformed with OFTEC. The UV package in all Borecene grades had been improved. Supplier information indicated that, based on their data, the package would be sufficient to give the necessary UV protection. Further the right type of green pigment would boost UV performance. The DuPont 8504 material was "*not in detail known to us*". The UV 8 performance indication from DuPont was very probably based on compression moulded samples (which, she said, would tend to give better results than samples which were just rotationally moulded).

366. She added:

> *"We realise that the UV results achieved in the Kingspan samples are not as good as both Kingspan and Borealis would like. We therefore propose that we discuss possible ways to improve the performance in the Borecene grade that Kingspan would like to work with in the future. Solutions could involve both improvements in base resin and in choice of pigment to boost performance".*

NOVEMBER 2002: BOREALIS' MARKETING TEAM MEETING

367. On **21-22 November 2002**, a meeting took place of Borealis' rotomoulding marketing team at which a power point presentation was produced. Ms Fatnes contributed to sections 8 and 9 of the presentation, entitled '*Enhanced Borecene'* and '*Borecene & UV Stability*'. Kingspan draws attention to the following aspects of the presentation:

i) It referred to Borecene having a UV package which gives 3-6,000 hours (depending on the test method) in a WOM before reaching 50% reduction in mechanical properties.

ii) It did not mention the Series H / Polimoon results.

iii) It acknowledged that;

"Existing package + green pigment (Kingspan dry mix RM8402) did not pass UV requirements in future EN standard for static oil tanks."

iv) It set out strategy options for the UV stability of Borecene. The strategy "*as today*" was recorded as being "*one UV package covering all needs*." Two further options were proposed, including "*Alt 2*", which was to differentiate UV packages in different grades: "*Example/ Oil tank grade with "high" UV"*. The presentation expressed the concern: *"will we get paid for the extra quality."*

368. On **27th November** Dr McDaid emailed Mr Shorter to give him further instructions about testing another RM 8402 sample. On **2 December** Mr Shorter emailed Mr Gregg a memo dated 29 November 2002 in relation to the tests carried out. The memo pointed out that outdoor exposure was, to date, the only real means of providing reliable information on the performance of a given stabiliser; and that some components could be detrimental to the light stability of LLDPE including pigment.

369. In the report Mr Shorter recommended, by way of general guidelines, the following appropriate loading levels of Tinuvin 783 for different UV performances for natural polymer:

UV 4	800 – 1,000 ppm
UV 8	2,000 ppm
UV 15	Min 3,000 ppm

370. His report emphasized (a) that some pigments could prejudicially affect the UV performance and the stability and dispersability of the stabilisation components; (b) that when discussing performance the whole formulation should be studied i.e. base polymer, pigment and typical pigment concentration, wall thickness etc; (c) that the UV stability of a rotomoulded part can be related to thickness, processing conditions, colour and pigment levels, dispersion of the pigment and location; and (d) that it was important to test the final polymer product.

Meeting with Borealis on 3 December 2002

371. On **3 December 2002** a meeting took place between Kingspan (Fred Rusk, Pat Phelan, and Dr McDaid) and Borealis (Ms Fatnes and Mr Halvorsen). Mr Wood probably was not there. There are two notes of this meeting which do not wholly coincide. Nevertheless the substance of what occurred is tolerably apparent from the two of them.

The Kingspan note

372. As the Kingspan note records, Borealis said that the only tank complaints in which they were involved were from DESO and Balmoral where the cracking was probably attributable to (i) poor product handling (the nature of which differed in each case) and (ii) the colouring process used by ICO who supplied both DESO and Balmoral with a grind blend version of RM 8402. Borealis had not received complaints on RM 8402 products using a dry blend powder mix as employed by Kingspan.

373. Borealis referred to the fact that tests (i.e. the KIWA tests) conducted by them on RM 8402 as currently supplied showed that the samples were expected to reach 50% EaB at between 6-7,000 hours[49] (and not the 10,000 hours required by the prEN standard) but said that such failure did not imply that the tank would then collapse. They said that they had not conducted UV tests on natural RM 8402 but had done so on other grades including RM 8342, using the same UV package.

374. The Borealis note records that Borealis did not have a lot of UV data for RM 8402 as most of the UV testing had been concentrated on RM 8342/3. I find this somewhat puzzling given that Series G had involved ME 8161 (=RM 8403) as well as ME 8169 (=RM 8343); as had Series H. But that may have been comparatively less than the testing on RM 8342/3.

375. The Kingspan note goes on to record that Borealis claimed that the stabiliser package in use in both RM 8402 and 7402 would meet the standard in natural samples[50] and suggested that the lower than expected results (i.e. the KIWA tests) were due to the pigment.

376. Borealis said that they did not rate their grades as UV4/6/8 and conceded that their package was equivalent to less than UV 6. This was, I infer, a reference to the B specimens.

The Borealis Note

377. As the Borealis note records, Kingspan questioned whether Borealis' UV package was good enough; and said that they gave a 10 year warranty. Borealis said that, based on supplier input, benchmarking with competitors and their own testing Borealis believed they had an "*industry standard UV package".* The note records that the test results indicated that the green samples may not pass the 10,000 hours in the WOM as required by the prEN Standard[51]; and that Borealis:

> *"explained that pigments can have a negative effect on UV and that some of the cheaper green pigments used may give negative influence. This information has become known to us recently[52]."*

[49] An extrapolation from Specimen B in the KIWA tests.
[50] Presumably a reference to the Polimoon results.
[51] That standard does not specify 10,000 hours but 10,000 hours in a Borealis WOM would be about 34GJ/m^2.
[52] An email of 12 June 2003 from Dr McDaid to the Banbridge operations director indicates that Kingspan's pigment supplier had been telling Kingspan in meetings from October 2002 onwards that different types of green pigment had different (including negative) effects.

378. Kingspan compares this statement with the representation in the Borecene Processing Guide that:

> *"When changing from a conventional material to a Borecene grade, the same pigments can be used, in the same quantity."*

379. The note records that Kingspan had used an external lab (i.e. the one used by Mr Shorter) to analyse RM 8402 which had found 700 ppm of Tinuvin 622 - see para 359 - "*but not the other half of the package which is Chimassorb 944"*. Borealis pointed out that it was necessary to analyse the full package and that Kingspan's result was misleading. Then, as the Borealis note records:

> *"Kingspan had also got advice (from Ciba?) regarding what is needed to to [sic] reach typical UV levels:*
>
> - *UV 4- 800-1000 ppm Tinuvin 783*
> - *UV 8 – 2000 ppm Tinuvin 783, or 2500-3000 ppm Tinuvin 622.*
>
> *We did not give the detailed recipe to Kingspan, but indicated that it is in between the recommendations for "UV4" and UV8", and closer to UV8 than UV4."*

The advice referred to was Mr Shorter's advice.

380. Ms Fatnes' indication that the "*recipe*" was in between the recommendations for UV 4 and UV 8 was incorrect (or, as she put it, "*I have misformulated myself. I am sorry about that*"). 1,300 ppm, the formulation for RM 8402 is closer to 1,000 ppm (and 800 ppm) than it is to 2,000ppm.

381. Borealis' note of the meeting goes on:

> *"We also informed them that RM7402 natural has passed the requested UV tests, and has an approval according to the similar standard for Chemical tanks (same UV requirements)."*

382. The reference to "*the requested UV tests*" must have been a reference to OFTEC or prEN13341 or both. Ms Fatnes sought to justify this statement in her oral evidence on the basis of the Polimoon tests[53]. But those tests were not carried out on RM 7402. She then said it must have been other tests that Mr Ervik had carried out for a customer which she had been told about. There is, however, no evidence before me of the results of any tests carried out on RM 7402, either to the OFS T100 or the preEN13341 standard. Borealis had carried out testing in 2000 on RM 7402 both internally and in customer trials including Seaplast in Iceland, Rhein Bonar in Germany, and Polimoon in Norway. The results were published on 13 November 2000 but these make no reference to UV resistance.

[53] In her first witness statement Ms Fatnes said that the statement was made on the basis of a number of tests: "*We informed Kingspan that natural RM7402 had passed UV tests (i.e. the tests we had carried out internally and at Seaplast, Iceland, Rhein Bonar, Germany and Polimoon Norway..."* (paragraph 243).

383. It seems to me that the reference to RM 7402 passing the tests was in fact a reference to the approval which had been granted by Norske Veritas under "*the similar standard for Chemical tanks*" (CENT/TC 266) which was based on the Polimoon results for RM 8403, 8343, and ME 8167. The letters referred to in the next three paragraphs confirm that it was an approval by reference to Polimoon tests to which Ms Fatnes was referring.

384. On **10 November 2002** Ms Fatnes had written to Mr Wood and Mr Borve, saying:

> *"Please find attached a first draft to a reply letter to Kingspan regarding UV performance of 8402. It may be of interest for you to know that Polimoon Cipax has got approval for natural 7402 based on tests according to the same standard that Kingspan wants to have the material approved against."*

385. On **17 December 2002** Ms Fatnes emailed Dr McDaid. She said that she had checked the QC records for the UV level of analysed batches of RM 8402 and the result was that they were all in line with the specification of 1,300 ppm Tinuvin 783 so that the lab result that Kingspan had received was, she believed, for some reason wrong. This made plain that the Tinuvin 783 content of RM 8402 was 1,300, which, if they were interested, Kingspan could relate mathematically to the figures of 800-1,000 and 2,000 ppm which Borealis had spoken of at the meeting.

386. She then said:

> *"2) Tank approval of RM 7402*
>
> *The UV approval for the grade was actually based on tests made on the three at that time older grades, RM8343, RM8403 (same grade as you use) and ME8166 (the MFR 3 grade which was the grade which RM7402 is replacing. All three grades (natural colour) passed the test criteria. Samples were taken from tanks made at the tank manufacturer and compression moulded and tested according to the standard in our lab."*

She then set out the Polimoon results. It seems to me that the approval being referred to is likely to be an OFTEC approval, since prEN13341 was not then in force.

Report into Balmoral failures

387. In the course of the meeting, Borealis distributed a draft final report into the reported oil tank failures at Balmoral and Deso, which was an updated version of the October presentation referred to at para 337 above. A section in the October presentation had repeated the contents of Dr Frøhaug's email of 4 October 2002: see para 338. However, in the report as presented to Kingspan changes had been made (they are marked up below to show the change but the fact of the change was not apparent from the presentation itself) as follows:

> *"10 years outdoor in North~~central~~ Europe corresponds to 10.000~~15.000~~ hr in Weather-o-meter (WOM*

> ***Results:*** We *have ~~some~~ data for natural (nonpigmented) Borecene. We have 65% retained tensile strength after 10.000hr in WOM ~~with 1750 ppm Tinuvin 783.~~ (about 6.5 year).”*

388. Mr Borve confirmed that it “*must have been*” he who prepared the amended slide. But he could offer no real any explanation as to why he made the alteration other than a suggestion that it might be that Dr Frøhaug came to him after she wrote her email and corrected it, “*but I don't know*”. Its effect was to withhold the fact that the tests had been carried out using Tinuvin 783 at a concentration of 1,750ppm, rather than the concentration in fact used in RM8402, i.e. 1,300ppm.

389. The draft final report removed the statement in the fourth bullet from the interim report that “*updated results from WOM test will be included in the final conclusions*” and instead inserted the fact that UV results would be best for black Borecene. Mr Borve was one of the team that decided on this change. He could not say why it was made. He, himself, was not aware of the Series J/KIWA test results that had been carried out on green samples (see para 343 above) and did not become aware until these proceedings. I find this surprising. Mr Borve accepted that, if he had known these results, he would not have felt able to make the statements in the presentation about Borecene, with “normal” amounts of UV stabiliser and a “normal” pigment having no problem lasting 10 years outdoors in central Europe (see para 338) without looking deeper into it.

390. The draft final report still contained a number of action points including:

> *“1.* ***UV*** *- is the amount we add sufficient for 10 years outside in Europe?*
>
> *Check with additive group + supplier (statement)”*

391. Mr Borve confirmed that no statement from any supplier was obtained. This was because with Balmoral (where the complaint did not relate to UV resistance) UV was not the issue.

The upshot of the meeting

392. Borealis concluded that the level of stabiliser would have to be increased in RM 8402 or 7402 to enable the material to meet prEN13341. Kingspan with assistance from pigment suppliers needed to establish the effect of the tank green pigment as a dry blend on the UV performance of the base material. Further testing was required to establish the minimum stabiliser level necessary to pass the prEN standard.

393. It was agreed that RM 7402 would be used in the future and a test program was agreed to evaluate the UV performance of natural polymer and the effect of green pigment, and the effect of using a stronger (compounded) UV package in natural and green pigment polymer.

Meeting with CIBA 17 December 2002

394. On **17 December 2002** Mr Gregg attended a meeting, arranged by James McGreer of the Irish Rotomoulders Association, with Andreas Thuermer from CIBA to discuss the implications of additive packages in rotational moulding and their effect on the weathering test for prEN13341. Mr Thuermer expressed the view that Tinuvin 783

gave far better results than Tinuvin 622 and that it should be used by material suppliers for tank grade materials in Europe; and that the dosage level should be 2,000 ppm to ensure a good chance of passing the weathering test. (It is not clear whether he was taking pigment into account or speaking only of natural polymer). He acknowledged that pigments could have a negative as well as a positive effect on the UV package and felt that the weathering test in the European standard was not good for rotational moulders because it required the samples to be compression moulded from the tank which meant they would undergo further heat degradation. In his view the test should be done on 3 mm rotomoulded plaques. He said that CIBA had carried out numerous short term tests to determine if any could be used to predict results from 10,000 hours weathering test but the results could not be correlated and were unreliable. An action plan was agreed involving, inter alia, his giving an opinion on each company's pigments and thereafter confirming the suitability of a Tinuvin 783 package for each material.

395. When he circulated his note of the meeting the next day Mr Gregg observed that he did not think that Borealis material at 1,300 ppm would have a chance of passing the weathering test and "*to be completely honest I do not think that they fully understand the whole area of UV packages*". This was based on a remark of Mr Thurmer to the effect that this was a very difficult area and he thought that Borealis might not fully understand it.

2003

PROPOSED RISE IN THE ADDITIVE LEVEL FOR RM8402 AND RM7402

396. Borealis continued to have doubts as to the adequacy of RM 8402. On 3 January 2003, Ms Fatnes emailed Mr Webster and Mr Borve, stating, in relation to the CEN standard expected to be in force in 2004, that:

> "*the natural RM8402 is very borderline with its existing UV package. Normally it has been believed that adding pigment would increase UV resistance. After this latest testing of the green samples it is clear there is no positive effect, maybe rather a negative one on UV resistance from the green pigment in question".*

397. She went on to say:

> *"The Kingspan group... want to be 100% sure to comply with the new coming standard. Without improved UV resistance they will not buy natural Borecene for oil tanks from us any more.*
>
> *Kingspan are according to Bob W. willing to pay more for an improved version (+15-20 E/t ?)."*

398. Ms Fatnes proposed an increase in the Tinuvin 783 concentration, and gave expected lifetimes in relation to the new packages:

"Grade	*UV Recipes today*	*Proposed new recipy [sic]*	*Expected lifetime (new recipy) [sic] in*

			WOM
RM 8402	*1300 ppm Tin 783*	*1500 ppm Tin 783*	*4-6000 hours*
RM 7402	*1500 ppm Tin 783*	*2000 ppm Tin 783*	*>8000 hours*
RM 8342	*1500 ppm Tin 783*	*Same*	*4-6000 hours"*

PROPOSAL

1) Launch RM7402 with improved UV stability as the Oil and Chemical tank grade.
Price premium above RM8402/ old RM7402 should be 15-20E/ton
This would then compensate for added UV cost which is approx. 10 E/ton

2) Adjust RM8402 UV level to that of RM8342 and old RM7402 (1500ppm) to get it on same level as the other products. (added cost 2,4 E/ton)"

399. Borealis did not convey to Kingspan any concern that 2,000 ppm would be needed for a lifetime in **excess of 8,000 hours.**

400. On **17 April 2003**, Dr McDaid wrote to Ms Fatnes indicating that CIBA had estimated that 34 GJ/m^2 corresponded to 9,500 hours in a 0.5 W/m^2 WOM. CIBA had advised the tank industry that a minimum of 0.2% of Tinuvin 783 would be required to comply with prEN13341 – the same figure as had been proposed for RM 7402 in Ms Fatnes' 3 January email. When asked about this Ms Fatnes said:

> *"You have to remember that, when CIBA is selling additives and giving advice, they will give advice to make 110 per cent sure that what they give is passing every kind of test..."*

401. Ms Fatnes forwarded Dr McDaid's email to Mr Webster and noted in relation to Kingspan's request:

> *"I have discussed with our additive people.*
>
> *Their advice is that we need min 2500 ppm Tinuvin 783 (today we have 1500 ppm) to match 9500 hours in Weather-O-Meter.*
>
> *This means an increase in additive cost from today's 25E/t to approx. 35 E/t. We know we already lose money on the oil tank business. Do we want to make an added cost product? Can we manage to get paid for it?"*

As before a principal concern as regards additives was cost.

402. In consequence of the advice of those concerned at Borealis with additives, on 6 May 2003 a new draft IPS for RM 7402 provided for the concentration of Tinuvin 783 to be increased to 2,500ppm of Tinuvin 783.

Further Test Results

403. There were further test results in 2003 namely:

i) updated test results in relation to Series C – the Florida Weathering (tensile impact) tests; and

ii) tests undertaken by Cytec comparing the UV performance of Tinuvin 783 against the performance of other additive packages (Series K).

UPDATED SERIES C RESULTS (CIBA PROJECT TA 12106)

404. After exposure to 734 Kly, Specimen L (the Ziegler Natta ME8152 specimen, stabilised with the standard package of Tinuvin 622 at 2,500ppm) had a higher tensile impact strength value compared to Specimen I (the Borecene ME8168 specimen, stabilised with Tinuvin 783 at a concentration of 2,500ppm) in both absolute and percentage reduction terms[54]. These results suggested that, even if stabilised with Tinuvin 783 at a concentration of 2,500ppm, let alone 1,500 or 1,300 ppm, the resin would perform somewhat worse in terms of resistance to UV/weathering than ME8152, stabilised with Tinuvin 622 at a concentration of 2,500 ppm.

405. But none of the specimens other than specimen B had failed after 734 Kly of exposure which is about 8-9 years in Northern Europe. Dr Botkin accepted that these results, and also those referred to in the next paragraph, did not suggest that there was anything in the molecular architecture of Borecene which meant that it had inherently poor UV performance or was inherently incapable of being stabilised.

THE SERIES K RESULTS

406. The Series K tests were carried out on natural samples which, according to Mr Jamtvedt of Borealis, had been rotomoulded by Cytec using their own machines. These results, which were for EaB and Tensile Impact strength, were performed using the Cytec WOM of 0.35 W/m². The results went up to 7,250 hours corresponding to no more than about 5 – 5.5 years of exposure in Northern Europe. Six formulations were tested. Formulation 1 (the reference resin, being the formulation used in RM 7402 incorporating 1,500 ppm Tinuvin 783) had fallen to 61% of its initial EaB value after 7,250 hours. That indicated that *natural* Borecene, even with an increase in concentration from 1,300ppm (the RM8402 formulation) to 1,500ppm (the RM 7402 formulation), was – on the assumption that figures from WOM tests could be directly related to actual performance - unlikely to provide protection against 10 years of weathering in Northern Europe.

407. The tensile impact strength results were worse. After 7,250 hours Formulation 1 was down to 49% of its initial tensile impact strength.

408. But the EaB tests indicated that Formulation 1 in natural Borecene would probably provide performance in excess of UV 8 i.e. about 6 years' worth in Northern European terms.

409. No results were obtained for Borealis' old additive package, i.e. Tinuvin 622 at a concentration of 2,500ppm, by way of comparison.

[54] Specimen L had a tensile impact strength of 23.5 J/cm^2, representing 80% of its initial value, whilst Specimen I had a tensile impact strength of 21 J/cm^2, representing 55% of its initial value.

2004

410. In **June 2004** Borealis was asked by Kingspan to issue a Letter of Conformity in respect of RM 7402. Mr Halvorsen emailed to Dr McDaid the following letter:

> *"This is to inform you that RM7402 – produced by Borealis AS – as supplied to KINGSPAN plc, when processed according to Good Manufacturing Practice, is expected to meet the material requirements of the OFTEC OFS T100 (May 1998 and prEN13341 (draft April 2003). That is:*
>
> *5. Weather Resistance (ISO 4892-1 & 2)*
>
> *34GJ/m2 irradiance, (equiv. To 800klys)*
>
> *Elongation at break greater than 50% of initial value*
>
> *(The material is expected to have Weather Resistance equiv. to 420klys)"*
>
> …
>
> - *Tests 3, 4 & 5 conducted on specimens prepared from samples taken from the moulded tank"*

411. Mr Halvorsen's evidence was that the 420klys figure came from discussions with Mr Didrichsen, who was not a witness, and Ms Fatnes and that he understood it to represent approximately 4,000 – 4,500 hours (not far off the appropriate number of hours in a Borealis WOM). Mr Halvorsen was asked about the contrast between the 2004 Letter of Conformity and what was said in December 2002:

> *"Q. You see we've looked together at the December meeting where you and Ms Fatnes, and I appreciate that you rather left it up to her to say so, where you've together said that 7402 had passed the required standard, which was the OFTEC standard of 10,000 hours, yes?*
>
> *A. Yes.*
>
> *Q. If you had known this at the time, then you would have had to say to Dr McDaid, "I'm terribly sorry, 7402 isn't sufficiently UV stabilised either", wouldn't you?*
>
> *A. But at least I know I was giving what I knew at that time so she is aware of what is actually happening.*
>
> *Q. I completely understand. What I'm putting to you is this, if you had known this, that the advice from Mr Didrichsen and others was that it would only withstand 420 kilo-Langleys, in December 2002, when you met with Dr McDaid and you told her that 7402 had passed the required standard, you wouldn't have been able to say that, would you?*
>
> *A. Maybe you are correct..."*

Whether or not Borealis would have been able to give the Letter of Conformity may depend on whether any figure cited refers to the natural or coloured Borecene. A natural material with an expected resistance of 400 Klys would not be expected to have a weather resistance of 800klys; but pigment would make a difference. Indeed the 2004 letter which refers to both figures must have contemplated the influence of pigment.

2005

SEPTEMBER 2005: MR ERVIK'S TECHNICAL REPORT

412. In around September 2005, Mr Ervik obtained a set of weathering tests on RM 7402, as set out in his report of **14 September 2005**, on the use of UV stabiliser in black rotational moulding grades. Carbon black was added to 8 of the 9 specimens, and tests were done on those specimens with varying concentrations of carbon black and different amounts of Tinuvin 783 stabiliser or none at all. The reference resin (sample 1) was left in its natural form, but stabilised with Tinuvin 783 at a concentration of 1,500 ppm (i.e. as per the RM 7402 supplied to Kingspan). EaB measurements were taken after 2,000 hours and 16,600 hours. The EAB value of sample 1 had fallen by 39% after 2,000 hours. Both Mr Ervik and Mr Halvorsen suggested that this was because the stabiliser was added in an unsophisticated and possibly defective extruder in the laboratory where the stabiliser would be exposed to air rather than in the course of commercial production. The other samples had reductions in EaB of only between 1 and 27% even after 16,600 hours.

THE CLAIM IN MISREPRESENTATION

413. With that inevitably lengthy introduction I turn to consider first, the law; secondly, what pleaded representations were made and whether they were false; thirdly, whether they were intended to be relied on and induced the contracts now in suit namely the several contracts for the supply of first RM 8402 and then RM 7402 between the beginning of 2002 and the autumn of 2003.

Which law?

414. As I have said, there is a dispute between the parties as to whether the claim in misrepresentation (if there is one) is governed by the law of England or the law of Denmark; and that question depends, in part, on which of those laws governs the contracts between the parties. At this stage I propose to assume that the applicable law is English law.

English Law

Section 2(1) of the Misrepresentation Act 1967

415. Where A has entered into a contract with B after a misrepresentation has been made to him by B, or B's agent, and as a result A has suffered loss, then B is liable to pay damages to A, unless B proves (i) that he had reasonable grounds to believe *and* (ii) that he did believe up to the time the contract was made that the facts represented were true: *Misrepresentation Act 1967* section 2(1).

416. The effect of section 2(1) is to make a representor who cannot prove reasonable grounds for a false representation liable as if the statement had been fraudulent. In effect the Act imposes an absolute obligation not to state facts which are untrue and which the representor cannot prove he had reasonable grounds to believe. There is no need for the representee to establish that the representor acted negligently.

417. A claim in misrepresentation may only be advanced by a representee. This includes (i) the persons to whom the representation is directly made and their principals; (ii) persons to whom the representor intended or expected the representation to be passed on; and (iii) members of a class at which the representation was directed: *Chitty (30th Ed.)* at 6-028.

The representation

418. A misrepresentation is a false statement of fact, as distinct from a statement of opinion - which is not to be regarded as a statement of fact merely because it turns out to be wrong. In certain circumstances a statement of opinion may be regarded as a statement of fact: *Chitty* at 6-007. A statement of opinion may be regarded as a false statement of fact if:

a) The person who expressed the opinion did not in fact hold that opinion; or

b) The person who expressed the opinion could not, as a reasonable man having his knowledge of the facts, honestly have held that opinion.

The first of these is in essence a case of fraud, which is not here alleged. The second is evidence of fraud and would only not be fraud in the case of a person who honestly thought what no reasonable person would think (a category of persons limited in number but not unknown).

419. A statement of opinion may carry with it an implied representation that the person making the statement has reasonable grounds for his belief: *Chitty* at 6-009, 6-011. Such an implied representation is likely to arise where the person expressing the opinion was in a position to ascertain whether or not it was true. Whether such an implied representation arises depends on the words used, the context in which they were used, the knowledge and experience of the speaker, the position of the parties, and how a reasonable person in the position of the person to whom they were addressed would have been entitled to understand them. If the misrepresentation alleged is that the person making the statement had reasonable grounds for his opinion/ belief, it will be for the representee to establish that the representor had no such grounds.

420. There is a category of statement, sometimes referred to as “puffs” and, in more modern language mere sales talk, which will not found a case in representation. This may be so where a statement is in such general terms as to be unverifiable.

421. Thus in **Dimmock v Hallett** [1866] LR 2 Ch App 21 a description in auction particulars that a farm’s land was “*fertile and improvable*” was said to be *“a mere flourishing description by an auctioneer*” which could not, save in extreme cases, be regarded as a misrepresentation, and a statement that the land “*in course of time may*

be covered with warp and considerably improved at moderate cost" was said to put "*a purchaser on inquiry, and if he chooses to buy on the faith of such a statement without inquiry, he has no ground of complaint*".

422. In **Johnson v Smart** (1860) 2 Giff 151 at 156, a description in auction particulars which described a house which the purchaser had not seen as "*substantial and convenient*" was held to be "*a description so relative in its terms to afford abundant opportunity for a conflict of evidence as to matters which are rather matters of opinion than of fact"*. But the Vice Chancellor does not appear to have ruled out reliance on it on that basis since he went on to decide that the allegation that the house was not substantially built was not made out and accepted, on the evidence of three surveyors, that the description was not untrue.

Intention

423. The representee must show that the representor intended him to act on the statement: **Banque Keyser Ullmann SA v Skandia (UK) Insurance** [1990] 1 QB 665,790. That was always the rule in deceit; and the latter case indicates that the same applies in a claim under section 2 of the Misrepresentation Act.

424. If a statement has more than one meaning, the question is whether or not it was understood by the representee in the meaning which the court ascribes to it - which is the meaning which would be attributed to it by a reasonable person in the position of the representee - and that having that understanding he relied on it. **Arkwright v Newbold** (1881) 17 Ch D 301; **Smith v Chadwick** (1884) 9 App.Cas 187. But for a claim in deceit it would be necessary to establish that the representor intended the representee to understand the representation in the sense in which he did or was willing that he should do so: see **Goose v Wilson, Sandford & Co** [2001] 1 Lloyd's Rep P.N. 189 paras 41,42.

Inducement

425. The representee must establish that he would not have entered into the contract if the representation had not been made – so called "but for" causation. It is not, however, necessary for him to show that the representation was the sole inducement. But it must have played a real and substantial part in causing him to enter into the contract: see generally **Raffeisen Zentralbank Osterreichen AG v RBS** [2010] EWHC 1392 (Comm); **Goose v Wilson, Sandford & Co**, para 41. In order to determine inducement, it is not always sufficient to ask what would have happened if the representation had not been made. A representation, once made, may bring something into mind the truth of which becomes a material cause of the representee entering into the contract, even if, had it not been made, the representee would not have thought to inquire about it: **Raffeisen**, para 197; **Dadourian Group International v Simms** [2006] EWHC 2973 (Ch), para 548.

Burden of proof

426. Once a representee proves that a statement was in fact false, the burden under section 2(1) shifts to the representor to prove that he had reasonable grounds to believe *and* did believe up to the time the contract was made that the facts represented were true. Where the negotiations for a contract have continued over a substantial time and the

misrepresentation was made some while before the contract was finally entered into, this burden may be a heavy one. It will not be sufficient for the representor to prove that he had reasonable grounds to believe the statement was true when made; he will have to go on to prove that he had reasonable grounds to believe and did believe the statement was true when the contract was made: *Chitty* at 6-075 & 6-019.

427. As is apparent from the previous paragraph, the relevant time for assessing the falsity or otherwise of the representations in issue and the reasonableness of the representor's belief is at the time when they are said to have been relied on i.e. when the contracts for the purchase of Borecene were made.

What representations were made?

Suitability for use

428. Borealis represented in its brochures that Borecene was suitable for use in the manufacture by rotomoulding of external oil tanks. This was a representation of the most general character.

UV stabilisation

429. Borealis also represented that all Borecene grades for rotomoulding were either "*fully UV stabilised*" (1996 Rotational Moulding Brochure; 2001 specification sheet) or "*UV stabilised*" (July 1998 and November 2000 Rotational Moulding Brochures; 1998 Processing Guide) and that RM 7402 was "*fully stabilised*" (May 2000 and May 2001 specification sheets). Borealis contends that these statements were too unspecific to amount to an actionable representation. Kingspan contends that in context they meant that Borecene had a stabiliser package which would preserve it from UV degradation for the expected lifetime of the product, which was 10 years.

430. I do not regard these statements as akin to a mere puff. In deciding what was being represented it is necessary to take into account a number of matters. First, the statements relate to natural Borecene. They say nothing about the effect of pigment or the moulded tank. Secondly the brochures and specification sheets were for general use, covering a large range of possible uses, rather than relating to any specific requirement of longevity, such as 10 years. Thirdly, the brochures which Kingspan received veered between "*fully UV stabilised*" and "*UV stabilised*". A reasonable reader who had received all the brochures, as PDC had, would wonder what the difference was. Fourthly, both expressions are unquantified and imprecise and beg the question, at any rate from an expert rotomoulder, as to what exactly the phrase signified, which such a representee could reasonably be expected to ask. Kingspan never asked what exactly "*fully UV stabilised*"/"*UV stabilised*" meant. What they did was to ask for details of UV weatherability when they sought the letter of conformity in 1999 and when Dr McDaid emailed Ms Fatnes on 13 November 2001.

431. In those circumstances neither the expression "*UV stabilised*" nor "*fully UV stabilised*", can, in my judgement, be taken as a representation that natural Borecene contained such stabiliser as would preserve tanks rotomoulded from it for whatever desired lifetime for rotomoulded tanks had been communicated to Borealis. It was no doubt implicit in that phrase that Borecene would have what could be regarded as a reasonable stabiliser package, looking at the question in broad terms in the context of

the rotomoulding industry as a whole, but not that Borealis was making a representation as to any particular UV package.

432. In any event, even if that be too narrow a view, Ms Fatnes' email of 18 November 2001 contained a recommendation that natural Borecene could be used for outdoor applications with an expected lifetime of about 5 years. Attached to it were slides which showed that lifetime had been estimated at 4,000 hours in a Borealis WOM based on the <50% EaB test. The relevant slide showed a lifetime of 4 years in Scandinavia. Another slide gave a lifetime of 6,000 hours based on Tensile Impact evaluation of 6,000 hours. Whatever "*stabilised*" or "*fully stabilised*" might otherwise signify, Kingspan could not reasonably have thought, after this, that it meant that *natural* Borecene was expected to last more than about that time.

Resistance to 22 GJ/m² irradiance

433. Borealis represented by its letter of conformity of August 1999 that RM 8402 (as ME 8160 became) when processed according to good manufacturing process was expected to meet the requirements of the OFTEC Standard namely weather resistance exceeding 22 GJ/m². It made a similar representation in 2004 in relation to RM 7402. But that cannot have induced any of the relevant contracts.

434. For the reasons stated in paras 156 - 158 above, that representation must be regarded, and was understood by Dr McDaid as, a representation that this result was expected when Borecene was used to manufacture green rotomoulded oil tanks.

435. The statement was a statement of opinion, not a guarantee or a warranty. It had to be such since as Kingspan knew, Borealis was not a manufacturer of tanks and had not carried out tests on any samples from Kingspan's green rotomoulded tanks (or, as represented by Ms Fatnes' email of 26 November 2001, any green tanks). Borealis did not know what pigment Kingspan used (other than that it was green, of which there are many varieties with different effects on UV resistance which may, in some cases, be prejudicial). Kingspan was reluctant to identify its pigment supplier. Dr McDaid of PDC knew by 2000 at the latest that pigments could improve weatherability, but that some could accelerate the degradation process: as was stated in an article on the Borealis website entitled *"UV stabilisers*", which Dr McDaid had seen.

436. I am satisfied that the letter impliedly represented that Borealis had reasonable grounds for expressing that opinion. Borealis, although not rotomoulders, were experts in polythene production. They were being asked, and agreed, to give a formal letter for the purpose of satisfying OFTEC and obtaining a full pass, as had been explained to them in Dr McDaid's fax of 18 May 1999. Kingspan was entitled to understand from the letter that Borealis had a reasonable basis for it. At the same time the representation had to be understood in light of the facts (a) that it assumed good manufacturing process; (b) that it was not, as Kingspan knew, based on any actual test of Kingspan's own tanks with whatever pigment, process and designs they had been manufactured; and (c) it was expressed as an expectation not an advice.

437. Dr Botkin, Kingspan's expert, accepted – in my view rightly – that anyone who received the letter of conformity knowing that there had been no test on one of his tanks would realise that what he was receiving was an opinion rather than any sort of definitive advice. He, himself, would have "*emphatically encouraged*" Kingspan to

do weathering tests on pieces cut from production tanks. He found it surprising that Kingspan had not done so; and would not have put his name to a product which had not been tested.

The email of 18th November 2001

438. Borealis made the statements which are set out in Ms Fatnes' email of 18 November 2001. I do not regard this email as a mere exchange of ideas. It included "*in general*" a recommendation that for UV exposed natural Borecene a lifetime of 5 years was expected; but for a lifetime of 10 years colours improving UV performance were needed; and for lifetimes in excess of 10 years black Borecene was recommended. I regard it as implicit in that recommendation, that there was a reasonable basis for expecting a 5 year lifetime for tanks made from natural Borecene and 10 for tanks made from green coloured Borecene. That representation was qualified by the observation that it was a recommendation made on the basis of a level of documentation which was less than Borealis would like to see – it would, therefore, need to be considered with some caution. It was not a representation that Borecene would have those lifetimes. Further, in respect of green pigmented Borecene it was an indication as to the potential doubling effect of a pigment, which the moulder would have to select and apply, as opposed to the natural Borecene which was all that Borealis supplied.

Were the representations false?

Suitability for use

439. Borecene was suitable for use in the manufacture by rotomoulding of external oil tanks. Kingspan themselves have manufactured tens of thousands of tanks that have not failed, even allowing for tanks that may have failed but whose failure has not been reported. Borecene has been used to manufacture tanks for use externally in, inter alia, Norway and the Philippines, as well as in other applications such as boats and tractor roofs. It was used successfully by firms such as JFC, a small rotational moulder in Ireland, who used RM 8343 for the manufacture of oil tanks; and by Uponor, a large Swedish firm for pipe systems and also for very large green tanks for those systems. It appears to have been used "successfully" in UV terms by Balmoral in the sense that, whatever caused those tanks to fail, it was not inadequate UV resistance. Professors Marshall and Malatesta and Dr Nugent all regarded it as suitable for rotomoulding oil tanks for external use. Dr Botkin accepted that it was possible to make tanks from Borecene lasting 10 years at any rate if you increased the thickness.

440. The critical question is the length of time that such tanks would withstand weathering. That is the subject of the other representations that are relied on.

UV stabilisation

441. The representation that Borecene was fully UV stabilised was not false. 1,300 ppm Tinuvin 783 was a reasonable UV package. Further, insofar as the representation about Borecene's UV stability boiled down, by November 2001, to an expectation that *natural* Borecene 8402 would last in the open for about 5 years that was not false either, in that there were reasonable grounds to hold that view for the following reasons.

442. The UV testing carried out by Borealis between 1997 and 2000 showed, as both Dr Botkin and Mr Malatesta confirmed, that Borecene performed in a broadly similar way to ZN grades which had been used for many years without giving rise to any problems. The basis for the figures in the 18th November 2001 email appears from the material attached to it. The 4,000 hours figure is based on EaB testing of ME 8169 (RM 8343) from the 30 October 2000 Series G tests, where the EaB test was failed by 3,000 hours, and the Series H Polimoon tests where the samples experienced practically no reduction in EaB even after 7,500 hours. 4,000 hours was, accordingly, fairly low down on the spectrum. The results for ME 8161/RM8403 in the two series also provided support for an expected lifetime of 4,000 hours.

443. It seems to me that based on that material Ms Fatnes was able reasonably to entertain the expectation that natural Borecene would last about 5 years. 4,000 hours in a Borealis WOM would amount to about 4 years in Northern Europe. The EaB test is a severe one and, to some extent, biased against Borecene because of the EaB test disadvantage point. A material which fails the EaB test is, as Dr Botkin accepted, likely to have a significant proportion of its mechanical properties intact. Failure of the test is, for the reasons explained in paras 67 - 71 above, not a reliable indicator of when a material will actually fail. In addition the Polimoon Cipax results were indicative of a UV 14 performance rating for RM 8402. This would amount to about 10 years on *natural* Borecene. The use of a 4,000 hours figure involved a substantial reduction from that figure.

444. In addition, as Dr Botkin accepted, the Cytec results in November 2003 on natural Borecene were evidence of performance in excess of UV 8, which represents around 6 years exposure in Northern Europe.

Resistance to 22 GJ/m² irradiance

445. Kingspan submits that, in light of the testing carried out by or known to Borealis, by the end of 2001, there was no reasonable basis on which Borealis could have suggested that Borecene, even with green pigmentation, was adequately UV stabilised or otherwise suitable for use in the manufacture of oil storage tanks in Northern Europe. The representations made to that effect were false.

446. I do not regard that as the relevant inquiry under this part of the claim. The representation in the letter of conformity was that RM 8402, if processed in accordance with good manufacturing practice, was expected to provide 22 GJ/m² resistance. The question is whether there was a reasonable basis for that expectation when Kingspan entered into the contracts to purchase RM 8402, namely from the end of 2001 or the beginning of 2002 until autumn 2002.

447. Borealis submits that it had reasonable grounds for that expectation because:

a) The UV testing carried out by Borealis and by CIBA showed that Borecene performed similarly to or better than ZN grade ME 8152, which had been used to manufacture products which survived in the field for many years, and which had received OFTEC approval; and was likely to perform similarly to ME8154, a ZN polyethylene produced by Borealis for the oil tank market, which had also so survived, and received OFTEC approval.

b) Ms Fatnes felt able to sign the LOC because of the previous approval of ME 8154, the similar level of UV protection in Borecene as in ME 8152 and 8154, and the Dyno tests which showed that with appropriate green pigment the necessary resistance would be achieved.

c) The Dyno test results - Series B – showed that green[55] Borecene ME 8169 (later renamed RM 8343) had failed by 5,000 hours exposure in the WOM whereas natural Borecene ME 8169 had failed by 1,500 hours. This showed that Dyno's green pigment could have improved performance of Borecene by 2 - 3 times. Mr Jamtvedt's evidence was that appropriate pigments would normally be expected to increase UV performance by a factor of 2 but that phthalocyanine green was known to increase it by 3, 4 or even 5 times according to CIBA publications and that with proper green pigment RM 8403 with 1,300 ppm could provide 900 Kly of resistance.

d) The letter of conformity was provided for ME 8160/RM 8402 containing the new stabiliser - Tinuvin 783 at 1,300 ppm. The Series D results showed that Tinuvin 783 at 1,500 and 2,500 ppm target levels was a similar or slightly improved stabiliser compared to the existing UV package of 1,500 ppm of Tinuvin 622 and would at least provide a performance very similar to Tinuvin 622 at 2,500 ppm, as used in Borealis ZN grades for many years.

e) The Series D test results for ME 8160 containing 1,415ppm of Tinuvin 783 showed that that sample would be close to failure after 3,300 hours (extrapolating the results linearly) in the Borealis WOM, which equates to a little over 10 GJ/m^2.[56] Ms Fatnes had in her possession prior to authorising signature of the letter of conformity both the Series D results and the Series B results of the Dyno tests, the latter showing that green pigments could provide a threefold improvement in UV performance.[57] In those circumstances Borealis had reasonable grounds for the statement of opinion in the letter of conformity that green rotomoulded Borecene tanks were expected to provide 22 GJ/m^2 of weather resistance.

f) The accuracy of the letter of conformity is supported by the results of the Polimoon Cipax tests (Series H), the KIWA UV tests (Series J – B samples), and the Cytec TSR♯02-EU-99 tests (Series K), which

[55] The green pigment used in the Dyno tests is unlikely to be the same as the green pigment used by Kingspan to manufacture their tanks.

[56] Professor Malatesta's evidence was that the UV performance of RM8402 containing 1,415ppm of Tinuvin 783 would be very similar to the UV performance of RM8402 containing 1,300ppm of Tinuvin 783: see para 454 below (Malatesta1:169).

[57] A CIBA document of January 2001 shows that when the UV performance of ZN rotomoulded HDPE plaques pigmented with phthalocyanine green was compared to the UV performance of similar unpigmented plaques, the UV performance of the former was 2.175 times as good as the latter. This was a different form of PE with a different stabiliser package; but gives some idea of the effect of pigmentation. Applying an uplift of 2.175 to the results of the Series D 1999 tests would mean that ME8160 when used to manufacture green rotomoulded tanks could provide 22GJ/m^2 of weather resistance.

showed, or at least provided evidence, that Borecene could be used to produce tanks that did not fail before 22 GJ/m^2 of irradiance.

g) The vast majority of Kingspan's tanks have been exposed for more than 22 GJ/m^2 of irradiance and have not been reported as failed.

448. I turn therefore to consider the *import* of the tests.

Series A

449. The Series A test showed that natural Borecene (both ME 8167 and 8169), when stabilised with Tinuvin 622 at a concentration of 2,500 ppm, failed the 50% EAB test after only 2,000 hours in the Borealis WOM. ME 8152 (Borealis' ZN) failed after 3,000 hours but, since there was no reading at 2,000 hours, it is impossible to say whether it had failed at that time. At 3,000 hours in terms of the percentage of the original percentage EaB ME 8152 did better (42% instead of 21/28%), but the actual percentages were quite similar (110% vs. 95 or 90%). Dr Botkin accepted that these results did not show a significant difference between the performance of Borecene and ZN resins. The black Borecene grades showed no reduction in EaB after 3,000 hours or 5,000 hours and did better in this respect than black ZN which had 79% of original EaB at 3,000 hours and 57% at 5,000 hours. This comparison suggested, as Dr Botkin also accepted, that there was nothing inherently wrong with Borecene.

450. I do not regard the comparison between ME 8152 and ME 8167 or 8169 as invalid because ME 8154 was Borealis' ZN tank grade. ME 8152, which was in fact used by ROM before Borecene, and ME 8154 have very similar densities (934 kg/m^3 compared with 940 kg/m^3) and could be expected to perform similarly.

Series B – the Dyno Tests

451. These showed the following results (for Borecene stabilised with Tinuvin 622 at a concentration of 2,500 ppm and ZN stabilised with Tinuvin 622 at 2,500 ppm) after exposure in a Borealis 0.51 W/m^2 WOM:

a) Natural ZN ME 8152 (MFR 3.6) failed the 50% EaB test by 1,000 hours in the WOM.

b) Natural Borecene ME 8169 (MFR 6) failed the test by 1,500 hours.

c) Natural Borecene ME 8167 (MFR 3.2) failed the test by 2,000 hours.

d) Green pigmented ZN ME 8152 (MFR 3.6) failed the test by 3,000 hours (a 3-fold improvement over natural – but the 2,000 hour position is unknown).

e) Green pigmented Borecene ME 8169 failed the test by 5,000 hours (a 3.33 fold improvement over natural).

These results showed (a) failure for the natural Borecenes after no more than 2,000 hours, which was a poor result; (b) better performance by both natural Borecenes compared to ZN; (c) a significant boost in UV stability when a green pigment was used; (d) a greater boost for Borecene, which, Dr Malatesta suggested, indicated that

Borecene was more stable than the ZN grade. The exact extent to which the pigment improved weatherability is unclear because the time by which failure had occurred is known but not the time at which it occurred. Even if failure occurred at 3,500 hours the improvement resulting from green pigment was over double. If at 4,000 hours the improvement was nearly 3 times.

Series C The CIBA Project TA 12106

452. This project involved tests on six specimens (5 Borecene: ME 8168 (RM 8342) – which Dr Botkin expected would behave in a similar way to RM 8402 - and 1 ZN: ME 8152). The artificial weathering results of July 1998 from exposure in a CIBA WOM of 0.35 W/m² showed the following:

a) The retained tensile impact strength of natural ME 8168, when stabilised with Tinuvin 622 at 2,500 ppm and Irganox B 215 at 1,800 ppm had fallen below 50% at 3,250 hours (Specimen B). But that specimen was probably affected by processing problems.

b) Specimen E with Tinuvin 622 at 2,500 ppm and 1,500 ppm of Irganox HP 2215 is (as Mr Jamtvedt explained) broadly comparable to Specimen B when properly prepared. (HP 2215 is 85% composed of B 215). It failed at 4,600 hours which is comparable to the 4,800 hours at which Specimen L – ME 8152 (ZN) with the same package as Specimen B failed. I accept that this suggests that Borecene was no more susceptible to UV degradation than ZN.

c) Specimen I - Tinuvin 783 at a concentration of 2,500ppm and 1,800 ppm B215 - had not fallen below 50% after 7,000 hours in the CIBA WOM (equivalent to c 400 Klys). A comparison between Specimen E and Specimen I showed that Tinuvin 783 had at least 52% better performance than Tinuvin 622.

453. If Tinuvin 783 shows at least 52% better performance than Tinuvin 622, that would indicate that 1,300 ppm of Tinuvin 783 would equate to at least 2,000 ppm of Tinuvin 622 and 1,500 ppm to at least 2,300 ppm. Those figures are a linear extrapolation.

454. But it was Professor Malatesta's opinion (based on research by Dr Gugumus in an article entitled "*Light stabilisation of metallocene polyolefins*" to which he referred) that the relationship between HALS concentration and UV stability is not linear: performance is proportionate to the square root of the concentration (i.e. if you double the concentration the performance is 1.41 ($\sqrt{2}$) greater). In that case 1,300 ppm would, on the basis of the Series C tests be the equivalent of at least 3,000 ppm and 1,500 ppm of at least 3,400 ppm. The mathematics which leads to that result is in **Appendix 5**.

455. I accept the validity of Professor Malatesta's opinion.

456. Mr Jamtvedt's evidence was that he was comfortable that 1,500ppm of Tinuvin 783 was an appropriate package for Borecene grades on the basis of these tests, a CIBA

brochure showing Tinuvin 783 performing several times better than Tinuvin 622[58] and discussions with CIBA in which they confirmed that 1,500 ppm of Tinuvin 783 would provide equivalent performance to 2,500 ppm of Tinuvin 622 (which had been used successfully for a number of years). RM 8402 only contained 1,300ppm of Tinuvin 783, and not 1,500ppm. But, on the footing that performance is proportional to the square root of the concentration, the difference of 200 ppm would only produce a reduction of about 7-8%. This is not an amount sufficient to explain the difference in failure between RM 8402 and ZN tanks.

457. The Florida weathering results of December 1999 showed that the retained tensile impact strength of ME 8168, when stabilised with Tinuvin 783 at a concentration of 2,500 ppm had not fallen below 50% at 2 years of Florida exposure.

Series D Borealis' tests

458. The Series D testing carried out by Borealis in its WOM showed the following:

a) ME 8160 (=RM 8402) stabilised with Tinuvin 783 at a concentration of 1,415 ppm (Ref 70354) had not failed after 2,500 hours in Borealis' WOM. It had also done more than twice as well as the ME 8167 and ME 8169 at 2,500 ppm Tinuvin 783 from an earlier test, although, in making any comparison account must be taken of the fact that one is comparing different studies. It is not unusual to see results vary from study to study (and there may be oddities in the same study arising from differences in the specimens used or the way they have been processed or the variability of the test). Nevertheless the difference is striking.

b) But the EaB reduction (62%) was scarcely better than the equivalent value for the reference sample - Borecene ME8161 stabilised with Tinuvin 622 at a concentration of 1,500ppm namely 61%. This did not say much for Tinuvin 783 compared with Tinuvin 622; but did nothing to suggest there was anything inherently wrong with Borecene stabilised with Tinuvin 783.

c) The other ME 8160 (RM8402) sample tested was sample ref 70355, a sample containing 2,760ppm Tinuvin 783. The test produced two unexpected results: (i) the EaB value prior to exposure was considerably lower than for the ME 8161 reference sample and sample 70354, when prior to exposure they could be expected to be the same; (ii) the results for 70355 indicated that increasing the concentration of Tinuvin 783 to 2,760ppm in ME 8160 did not result in any significant improvement in performance compared to 1,415ppm Tinuvin 783, which is not what you might expect. If the 2,760 ppm sample (Ref 70355) is assumed to have had the same starting figure (i.e.1,450%) for EaB as the 1,415 ppm (Ref 70354) the EaB at 2,500 hours was 55% in the former and 62% in the latter. The result would, again, have indicated that a considerable increase in concentration of Tinuvin 783 did not increase the performance.

[58] Figure 16 in the CIBA brochure "*Light Stabilisers for Polyolefins*".

Series E The Cytec Tests

459. This was a test on unidentified ZN specimens. All of them had failed the EaB tests within 10,000 hours in Cytec's WOM (0.35 W/m²). The grade stabilised with Tinuvin 783 at a concentration of 3,000ppm had failed within 8,970 hours. This lifetime exceeded 22 GJ/m^2 (on Professor Malatesta's approach). This was at a concentration of more than double that contained in the RM 8402 supplied to Borealis. At the same time the Series D tests had indicated that there was not a great deal to be gained (if anything) by increasing Tinuvin 783 from 1,415 to 2,760 ppm in the case of Borecene. The ZN stabilised with 3,000 ppm Tinuvin 622 failed at 3,760 hours i.e. in about 42% of the time.

Series F The CIBA Project TA 12492

460. The primary purpose of this project was to assess the effectiveness of different antioxidants. Borealis attributes significance to specimen 8, containing a 1:1 blend of Tinuvin 622 and Chimassorb 2020 in ME 8168. This retained 77% of its tensile impact strength after 10,000 hours in the CIBA WOM operated at an irradiance of 0.35W/m^2 at 340nm. Mr Jamtvedt regarded the 1:1 blend of Tinuvin 622 and Chimassorb 2020 (similar to 944) – Specimen 8 - to be similar to Tinuvin 783 and said that the results (which also included the sample doing well (c 65%) at 16,000 hours) therefore gave him confidence in the UV performance of Tinuvin 783 in Borecene.

Series G Borealis' EaB and Tensile Impact tests

461. These tests concerned 3 unpigmented resins - one ZN ME 8152; and two Borecenes ME 8161 (= RM 8403) and ME 8169 (RM 8343). The significance of the results seems to me as follows :

Elongation at break

i) At 3,000 hours in the Borealis WOM (about 300 Klys) the EaB value of ME 8169 (RM 8343), stabilised with 1,500 ppm of Tinuvin 783 had fallen to 48% of the initial value, equivalent to approximately 10 GJ/m^2.

ii) At 3,000 hours the EaB value of ME 8161 (RM 8403), the powder version of ME 8161 (RM 84032), stabilised with 1,300 ppm of Tinuvin 622 had fallen to approximately 45% of initial value.

iii) Both Borecenes had done better than the ZN – ME 8152, stabilised with 2,500 ppm of Tinuvin 622 - which had failed at 1,000 hours. That comparison needs to be looked at with considerable caution. The EaB figure for ZN at 1,000 hours is surprisingly low.

iv) The comparison between ME 8161 and ME 8169 indicated that reducing the quantity of Tinuvin 783 stabiliser had very little effect.

Tensile Impact Strength

a) At 3,000 hours the retained tensile impact strength of ME8169 (RM 8343) was 82% of the initial value; which was a good result.

b) At 3,000 hours the retained tensile impact strength of ME 8161 (RM8403) had nearly halved, only just exceeding the 50% level.

c) Ms Fatnes' evidence was that she would have expected RM 8343 and RM 8403 to behave in a similar way and she, therefore, regarded the results for RM 8343 as a reliable indicator of the performance of RM 8403. There does not seem to me any sound basis for inferring the performance of RM 8403 from the results of RM 8343 rather than from the results of RM 8403 itself, subject to the point that if two results are expected to be the same and differ significantly it is possible that one is unrepresentative and, if so, it is not possible to be sure which one it is.

d) At 3,000 hours the ZN had had no reduction in properties. Indeed the relevant value had gone up by 14% from the original. But that result is suspect.

Taken as a whole these results provided no support for the proposition that *natural* Borecene 8161 (8403) would satisfy either 50% test after the hours in the Borealis WOM equivalent to 22 GJ/m^2 i.e. about at least 6,000. A boost of something like a factor of two from pigment would be necessary. They also provide no support for the proposition that there was such a difference as between ZN and Borealis resins as would explain the very marked difference in failure rates.

Series H The Polimoon Cipax Tests

462. These EaB tests, showed that, after 10,000 hours of exposure in the Borealis WOM, 1 mm compression moulded samples of Borecene RM 8343, RM 8403, and ME 8167 had only experienced 30%, 17% and 25% reduction in EaB values i.e. they were not even close to failure. 10,000 hours represented about 37.5 GJ/m^2, on Professor Malatesta's basis. Taken at face value the results indicate that natural Borecene could easily pass not only the 22 GJ/m^2 test but also the 37.6 and 34 GJ/m^2 tests. If, as Kingspan contended, the tests were carried out on the old 8403 package (1,500 ppm of Tinuvin 622, and not 1,300 ppm of Tinuvin 783), the results were even better.

463. The fact that the tests were carried out on 1mm compression moulded samples does not, as it seems to me, rob them of significance.

464. The OFTEC Standard requires testing to be carried out either on samples cut from the moulded tank or from compression moulded sheets moulded from pieces from the moulded tank. The OFTEC Standard, by various cross reference set out in the footnote[59] specified a preferred thickness of 4mm +/- 0.2 mm for the tensile tests

[59] Section 5.1.3 of the OFTEC Standard prescribes the test method for the tensile test for Tensile Properties specified in section 4.1.4, namely that it shall be carried out in accordance with ISO 527, Specimen type 1. It does not, however, specify which of the 3 parts of ISO 527 is applicable. But the ISO 527 – 2 Standard (described as "*Test conditions for moulding and extrusions plastics*") specifies the preferred thickness of a type 1 specimen as 4mm. The prEn standard specified (at A.1.3, incorporated by Table 1) ISO 527 – 3, sample type 5

specified by section 4.1.4 which calls for the original EaB to be greater than 200%. It does not in terms deal with the specimen for the weather resistance test. The prEN13341 and KIWA draft standards required 1mm compression moulded samples.

465. In circumstances where both standards permitted or called for compression moulded samples it is not realistic to dismiss results derived from them. The 1m prEN14431 requirement was, under pressure from rotomoulders, including Kingspan, later changed to 3 mm. The complaint was that the 1 mm sample was unduly prejudicial to the material: see para 74 above.

466. If comparison is to be made between 1 mm compressed and thicker rotomoulded samples, a number of considerations arise. It was Mr Jamtvedt's evidence (a) that he had a feeling that using a thinner sample than the rotomoulded sample would have "*given higher figures or long – less reduction over time*"; (b) that 1mm thick compression moulded samples were normally used for plastic film; and (c) that the compression moulding process would have artificially improved the sample as compared to the tank's post-rotomoulded (but uncompressed) state by taking out surface defects. The compression moulding process meant that the sample not only was "*a better product"* but also that it was "*a different product*" in that the process eliminates *"both surface imperfections and any bubbles that there may be*".

467. But he also said that thicker samples would be expected to have greater, and thinner samples less, weatherability; and that testing on compression moulded samples was more reliable in that with rotomoulded samples performance can be affected by defects, particularly surface defects in the sample, rather than its UV stability. Both points seem to me valid. Further compression moulded samples will suffer heat degradation in the process of compression. Mr Thuermer of CIBA regarded the test as not good for rotomoulders for that reason.

468. In circumstances where the draft European and KIWA standards mandated 1mm compression moulded samples for the weathering test I do not find the critique based on the fact that such samples were used particularly persuasive, although Ms Fatnes was, herself to deploy the point later: see para 365. I note that Den Norske Veritas accepted these results.

469. It seems to me that Borealis was entitled to take, as they did, considerable comfort from these figures, which represented exposure over a very sizeable period of time, and produced very comparable results from the same test conditions for 3 different Borecenes, including RM 8403. As Dr Botkin agreed, taken at face value the results were inconsistent with the proposition that it was not possible to stabilise RM 8402 adequately or that it had inherently weak UV performance.

The Series I tests

470. These WOM tests were carried out at an irradiance setting of $0.35W/m^2$ on ME 8168 using 4 different formulations of stabiliser. Their purpose was to assess the UV performance of different formulations at two different processing cycle times using

---

and provided that a compression moulded sample of 1 mm thickness should be used. ISO 527-3 (described as "*Test conditions for films and sheet*") sets out - both for specimens type 1B and 5 - a sample thickness of 1mm or less.

both the tensile impact test method and the elongation to break test method. The results show that at 14 minutes and 18 minutes, cycle time Cyasorb UV-4611 (formulation 5) performed better than Tinuvin 783 (formulation 2), although the difference in the performance of those formulations was not significant in the tensile strength tests.

471. The details of the results are set out in paras 288 - 292 above. The EaB results for Tinuvin 783 showed failure in the 14 minute cycle at 4,000 hours. This was not a good EaB result for Tinuvin 783. But in the tensile strength tests failure had not occurred at 10,000 hours.

Conclusion

472. In determining whether Borealis had reasonable grounds to express the opinion it expressed in the letter of conformity it is necessary to take into account a number of factors including (a) the range of the EaB results, in some of which ZN material itself fared badly; (b) the high standard variation to be expected from such results, which will differ according to the circumstances of the test, the process by which any tank has been rotomoulded, any compression moulding effected and any sample prepared, and which will on occasion produce odd features; (c) the fact that whilst natural material was being supplied, it was expected to be strengthened by an appropriate pigment and rotomoulded in accordance with good practice.

473. Having considered the plethora of material and the parties' submissions as to its significance, I do not regard it as established that Borealis did not have reasonable grounds to expect that green pigmented RM 8402, rotomoulded in accordance with good manufacturing practice, would meet the 22 GJ/m^2 test. In my judgement it did have such grounds.

474. I regard the matters relied on by Borealis as set out in para 447 above as providing a reasonable basis upon which Borealis was entitled to hold the view that it expressed – that view being held up to the time at which the relevant contracts were entered into by Ms Fatnes who signed the letter of conformity and by Mr Jamtvedt.

475. Previous experience with ME 8152 and 8154 indicated that ZN polyethylene was capable of lasting for many years without being adversely affected by weathering. The Series B Dyno results and other material, e.g. from CIBA, made it reasonable to expect that the appropriate green pigment would increase the durability of the polymer in EaB terms by at least a factor of 2 and probably nearer 3 times. Series C results showed how much Tinuvin 783 was an improvement on Tinuvin 622. The Series D results for ME 8160 (RM 8402) indicated failure in EaB terms at above 10 GJ/m^2. Applying a reasonably to be expected factor to allow for pigment would take the figure to well above 20 GJ/m^2. The Series H Polimoon results placed the failure figure for natural material way above 20 GJ/m^2.

476. In the light of those matters I do not regard the contra indications from the results as making it unreasonable for Borealis to entertain the expectation. Series F contained tensile impact results, which Borealis and KIWA favoured, two of which (Specimens 1 and 4) with Tinuvin 622 at 2,500 ppm involved a reduction below 50% at 6,000 hours (itself about 15 GJ/m^2.); but with much better results for other specimens, particularly specimens 5, 7, and 8 none of which came close to 50% reduction even at

10,000 hours. The Series G ME 8161/RM 8403 sample had failed in EaB terms at 3,000 hours but that was equivalent to about 10 GJ/m² for an unpigmented sample. The Series I EaB (but not the tensile impact) results were unfavourable; but they were only one set of results under processing conditions which may or may not have been optimal for the processing of Borecene.

477. In this respect I regard the Series H Polimoon results as of some importance. It is obviously necessary not to pick the cherry from an otherwise unpalatable cake. But for the reasons set out in para 465 – 469 above, the results seem to me of particular significance. They were a firm indication of what could be achieved. An expectation could not reasonably be founded on a freak result or one that could only be achieved by extraordinary expedients. But there was no reason to regard either of those characteristics as present. That these results were obtained was an indication that good manufacturing practice could be expected to produce acceptable results; and the figures were such as to allow a generous margin of error.

478. The Series I tests had poor results for Borecene with 1,750 ppm Tinuvin 783 but in the tensile impact tests failure had not occurred by 10,000 hours in a CIBA 0.35 W/m^2 WOM, which would equate to about 22 GJ/m^2.

479. The Series J and K tests were carried out after Kingspan began to purchase Borecene and, in the case of the latter, at about the time when they were ceasing to do so. In relation to the Series J test in October 2002 the 1 mm compression moulded samples – as called for by prEN13341 had reached about 69% of initial EaB after 4,000 hours in a Borealis WOM which would suggest an expected lifetime of between 6,000 and 7,000 hours which would meet the 22 GJ/m^2 requirement. This was a significantly better result than a test of similar samples of green pigmented Dow NG 2432 tested by RAPRA in 2005 which experienced more than 50% reduction in EaB after 3,000 hours: see para 73 above.

480. The Florida Weathering tests on natural samples were in August 2003 all performing well, save for Specimen B, after 4-5 years exposure which was equivalent to 7-9 years in Northern Europe.

481. The Series K results in November 2003 which Mr Jamtvedt expected were carried out on 3-4 mm natural rotomoulded samples showed, in the case of Sample 1, which had a very similar stabilisation package to RM 8402 (albeit with 200 ppm less Tinuvin 783) that it had only experienced about 40% reduction in EaB after 7,250 hours in a 0.35 W/m^2 WOM, equivalent to UV 8, in the order of 19 GJ/m^2. These Cytec tests were more favourable than the previous Series I test – a difference which may reflect a different processing.

Reliance

482. In those circumstances it is not necessary to determine whether Kingspan relied on the letter of conformity in the sense that but for that letter (or but for that letter and other things) it would not have entered into the contracts for RM 8402.

483. Borealis say that the relevant reliance is not established for a number of reasons:

a) the letter of conformity was by the end of 2001 two years old;

b) in November 2001 Kingspan was given information about testing from which Kingspan could judge for themselves whether the 22 GJ/m^2 test would be satisfied;

c) the real reason why Kingspan bought Borecene, which they had been considering since 1996 was because in October 2001 the price of it had dropped, and it was readily available in the quantities that they needed;

d) although Dr McDaid recollected that the letter was sent to Athlone, there is no documentary evidence of that, and it must be doubtful whether it was sent;

e) Kingspan continued to purchase RM 8402 even though no letter of conformity was ever given, although sought, stating that Borecene was expected to withstand 34 GJ/m^2;

f) Kingspan purchased RM 7402 without asking for, much less receiving, a letter of conformity until June 2004; as the evidence of Mr Rusk shows, he was not informed of the absence of such a letter, and would not have bought that material it if he had known there was none;

g) Tyrell, Rom and GSP cannot be said to have relied on any representation in the letter of conformity because only Titan obtained any form of approval from Athlone - in the report of 4 June 1999;

h) Kingspan adopted a tick-box attitude to the OFTEC standard, being uninterested in the substance of compliance rather than having the means, via a letter of conformity, of avoiding having to carry out section 4.1 tests themselves; and

i) Kingspan used, as Dr McDaid confirmed, both Dow NG 2432 and Resilin 8504 without any letter.

484. As to (g) there is no satisfactory evidence that any tanks made from RM 8402 other than those sent by Titan which were the subject of the report of 4 June 1999 were ever sent to Athlone, or reported on by Athlone. Two factory witnesses from Tyrell at Portadown (Mr McQuillan and Mr Doran) recalled Borecene RM 8402 245 tanks being sent to Athlone; and Mr McQuillan recalled being told that they had passed the test but neither could recall when this was. An email from Mr Atterbury of Athlone of 5 February 2002 does not list Borecene made tanks as amongst those approved for Tyrell by Athlone. No testing report has been produced and it seems to me unlikely that any such report, which would be readily discoverable, was ever made. The factory witnesses from Rom and GSP had no recollection of tanks being sent to Athlone for testing. Whilst there is evidence that Tyrell and GSP sold their tanks as OFTEC approved, Mr Egan gave evidence that Rom, to the best of his knowledge did not.

485. Whilst I see the force of these submissions it seems to me that Borecene would not have been purchased by any of the claimants if no letter of conformity had been produced, after it had been asked for. Kingspan’s laxity in not obtaining any report other than that of 4 June 1999 and not obtaining any letter of conformity other than

the 1999 one, does not in my view mean that the absence of any letter at all in relation to Borecene, a new material, would have made no difference.

486. Borealis makes a more general submission as follows. Mr Rusk, who made the decision to purchase Borecene and who was not a technical person, said that he did so on three bases (a) price; (b) availability and (c) the ability of Kingspan to market their tanks as being OFTEC approved. He was not, therefore, concerned with the accuracy or otherwise of the letter of conformity or anything that was said about the performance of Borecene. Moreover both Dr McDaid and Mr Gregg said that they did not communicate with Mr Rusk to tell him of the various properties of Borecene. So the information which is said to amount to a misrepresentation was given to those who did not decide to purchase, and the man who did decide could not and did not rely on information which he was not told about.

487. I regard this as too simple a view. PDC (in the shape of Dr McDaid and Mr Gregg) provided expert advice to the Kingspan Group. If, absent a particular representation, they would have advised against the purchase of Borecene, Kingspan, in the form of all the claimants, may properly be regarded as having relied on the representation, once given. Further the fact that Mr Rusk wished to be satisfied as to the ability of the claimants to market their tanks as being OFTEC approved itself shows that, if no letter of conformity of any kind had been provided when asked, of which he would be likely to have been informed, the purchases would probably not have gone ahead.

The email of 18th November 2001

Falsity

5 and 10 year lifetimes

488. The basis on which Ms Fatnes made the statements as to expected lifetimes appears in the email of 18 November 2001 and its attachment. The expected lifetime for *natural* Borecene of 4,000 hours based on EaB is based on the Series G results which show a figure of about 3,000 hours and the Series H Polimoon results where there was no reduction in EaB even at 7,500 hours. The comparable figure based on tensile impact, which Ms Fatnes regarded as more reliable, was 6,000 hours. 5 years was, as it seems to me a reasonable, and probably a modest, estimate for the actual service lifetime in unpigmented form.

489. So far as the expected lifetime of green pigmented Borecene is concerned, the upshot of the Dyno tests – Series B – and the CIBA document referred to in footnote 57, gave, in my view, Ms Fatnes reasonable grounds for expecting, as she did, that green pigment would at least double the lifetime of natural polymer and probably nearer triple it; such that green pigmented Borecene could be expected to have a lifetime up to 10 years, particularly when she had made clear that her expectation was on the basis that there was less documentation available than Borealis would like; and when the data on which it was, at least in part, based, was attached for Dr McDaid, who has a Ph.D and is an M.SC, to study, as she did. Ms Fatnes was also entitled to take into account as supporting that view the fact that Kingspan's green ZN tanks had survived for more than 10 years without incident so far as weathering was concerned.

490. Further these recommendations were based on EaB or tensile impact tests where failure is defined as reaching a 50% reduction from the original measurement. That is a very conservative test. Actual service life could reasonably be expected to be markedly longer.

491. In those circumstances it is not necessary to determine whether Borealis had the necessary intention or whether the representations about 5 and 10 year lifetimes induced the relevant contracts. I shall, however, consider these questions shortly.

Intention

492. Both Ms Fatnes and Dr McDaid agreed that the statements in the 18th November email were not made with the intention of procuring Kingspan to buy Borecene (although Borealis' overall aim was to encourage sales) but to provide information as to the testing which had been done, in response to Dr McDaid's request in her email of 13 November for information/results on long term weathering properties of RM grades. It was KIWA which sought this information which Kingspan wanted to provide because it was looking to supply the Dutch market.

493. In **Goose v Wilson, Sandford & Co** Morritt LJ said this:

> "*48. The third criticism arose from the judge's summary of the third principle he deduced from the speech of Lord Maugham in <u>Bradford Third Equitable Benefit Building Society v Borders</u> [1941] 2 AER 205, 211 namely that the representor should have intended that the representation "should be acted on by the plaintiff...in the manner which resulted in damage to him". It was suggested at one stage in the argument that this formulation wrongly restricted the requisite intention.* ***We would agree if the statement was taken to require the representor to intend to induce the specific action taken by the representee in reliance on the misrepresentation****.* ***The more normal formulation is that the representor should intend to deceive the representee, with intent, that is to say, that it shall be acted upon by him****. Clerk & Lindsell 17th Ed. Para 14-29……... But, in any event, there is no indication in the passage from the judgment of Rimer J that he did in applying the principle wrongly restrict it. He referred to the absence of any intention on the part of Mr Wilson to induce Mr Goose "to enter into any transaction" or "to commit himself to anything". He considered that the Stones were "simply irrelevant to any liability to which he might be prepared to subject himself". These were findings of fact open to the judge on the evidence before him."*
> [Bold added]

494. Borealis submits that the necessary intention has not been established since the 18 November email was not written or understood to have been written to induce Kingspan to enter into any transaction.

495. However, the email must have been intended to be acted upon by Kingspan for the purpose of conveying the information in it as to the weathering properties of Borecene to those who sought it, and also for Kingspan to take into account for themselves in relation to their own use of any Borecene, which they were about to purchase for their existing markets, and might purchase for their contemplated new one. Not without some hesitation I regard that as a sufficient intention for present purposes.

Inducement

496. In determining whether or not A was induced by B's representation to enter into a contract the answer is generally to be found by asking what A would (or would not) have done if no representation had been made. Arriving at an answer may be assisted by asking what A would have done if he had been told the truth (as to which "truth" see ***Raffeisen**,* paras 192 - 194).

497. In the present case the email of 18 November 2001 followed the request in the email of 13 November 2001. That request was not made by Mr Rusk who was making the purchasing decision. By this date arrangements for the future purchase of Borecene were well in hand and Borealis had quoted their terms. The 18 November email was not sent to Mr Rusk. It does not appear to have been discussed internally, or at least not in any way that has been recorded. Mr Gregg did not see it nor learn of its contents; nor did Mr Rusk. Dr McDaid's evidence was that she relied on its contents. But there is no direct evidence as to what would have happened if Borealis had either said that they had no information to give, or had declined to give any information that they had, although the absence of that evidence is not conclusive.

498. In my judgement the email played a real and substantial part in causing Kingspan to enter into the contracts for the purchase of Borecene. It contained important information about the weatherability of Borecene, given in email as opposed to brochure form. If Borealis had said they had no information about 10-25 year weatherability, or were not prepared to give what information they had, that would probably have raised questions about the wisdom of purchasing Borecene. At this stage Kingspan was already minded to purchase Borecene. But a representation may induce even though its effect is to cause the representee to persevere in a decision already made: ***Barton v County Natwest*** [1999] Lloyd's Rep Banking 408, paras 55-6. The fact that it was made to Dr McDaid, and not Mr Rusk, is not fatal if it confirmed to her, Kingspan's technical adviser for this purpose, the acceptability of Borecene. It seems to me that, the email of 13 November 2001 having raised the question of 10 year weatherability, Kingspan would not have proceeded with the purchase unless Dr McDaid had some response such as that contained in the email of 18 November 2001 which was acceptable to her.

Doubling the lifetime

499. The 18th November email contains the sentence: "*The RM8402 UV package was improved to double the lifetime of the Borecene grades vs. ME8152".* This sentence is part of the explanation as to the basis upon which the 1999 letter of conformity had been given "*before a lot of data was available*".

500. This statement appears to have been intended to reflect the results of the Series C CIBA tests on ME 8168/RM 8342 using Tinuvin 622 and Tinuvin 783 respectively. Results from Specimens B and I from the Series are expressed on the graph attached to the email. Specimen B with 2,500 ppm Tinuvin 622 failed the tensile impact strength test at 3,250 hours. Specimen I with 2,500 ppm Tinuvin 783 had not failed by 7,000 hours i.e. more than twice as much. But specimen B appears to have had processing faults, which the compiler of the graph and Ms Fatnes may not have appreciated. A comparison between Specimen E and Specimen I, the former with 2,500 ppm Tinuvin 622, which failed at 4,600 hours and the latter with 2,500 ppm

Tinuvin 783 which had not failed at 7,000 hours showed Tinuvin 783 to be at least 52% better: how much better would depend on when Specimen I actually failed. That was a comparison between different stabilisers in the same Borecene. A comparison between Specimen I and Specimen L, the ZN, showed Tinuvin 783 to be at least 45% better. Since the RM 8402 UV package was said to double Borecene lifetime by comparison with ME 8152 that was, prima facie, the appropriate comparison (although the fourth slide made clear that the comparison in it was with RM 8343).

501. The comparisons in the previous paragraph are all between polyethylenes with the same concentration of stabiliser. But RM 8402 was to have 1,300 ppm 783 and not 2,500 ppm. In those circumstances even if Tinuvin 783 was 50% or 100% more efficacious than Tinuvin 622, the lifetime of a polymer incorporating a *lesser* quantity of the *stronger* package would not be expected to double the strength of the whole, unless, perhaps, the efficacy of Tinuvin 783 was, somehow, spent once a given dosage was achieved. However, as an additional complication, it is probably the case that UV performance is proportional to the square root of the concentration with the result (see paragraph 454 above) that, on the Series C results (Specimens I and E) 1,300 ppm Tinuvin 783 could be expected to give *equivalent* performance to 3,000 ppm of Tinuvin 622. It would not however, on those results, give *double* the performance of 2,500 ppm Tinuvin 622. It might be doubly efficacious as a stabiliser; so that having a lesser amount of stabiliser produced the same or a somewhat better result; but that would not mean that the grade (with a lesser amount) was twice as good.

502. Support for the statement can, however, be derived from the Series D results. There ME 8160 with Tinuvin 783 at 1,415 ppm had not failed at 2,500 hours when the EaB was 900% (62% of original). By contrast two specimens from an earlier test with Tinuvin 622 at 2,500 ppm on ME 8167 and ME 8169 (both Borecenes) had each failed at 2,500 hours at 300% which was 29% of the original. On that footing Tinuvin 783 was at least twice as efficacious and on a smaller concentration in Borecene.

503. These were the tests available when the letter of conformity was given. Prima facie, the accuracy of the statement that the letter of conformity was given on the basis that the RM 8402 package was improved to double the lifetime falls to be determined as at that date. I have come to the conclusion that Borealis did not have reasonable grounds to make that statement. It was put forward on the basis of the Series C results which, once it is appreciated that Specimen B was probably defective, do not support the proposition. The Series D results do provide some support but not enough, in my judgement, to make it reasonable to make the statement. The comparison is between different tests and between stabilisers in different Borecenes.

504. Insofar as the effect of the misrepresentation continued it is necessary to look at the subsequent results although they are unlikely to produce support for a statement which relates to the genesis of the 1999 letter of conformity.

505. The Series E results, which were all on ZN material with stabilisers at 3,000 ppm showed failure at 8,970 hours in the case of the Tinuvin 783 and 3,760 hours in the case of Tinuvin 622 i.e. over twice as long. That was, of course, a higher concentration of 783 and in a ZN material but, since the concentrations were in identical amounts, the results afford a comparison of the efficacy of the stabiliser.

506. The Series G test results published on 30 October 2000 showed that RM8403 (then ME8161), with 1,300ppm of Tinuvin 783, performed significantly better than ME8152, with 2,500ppm of Tinuvin 622 in the EaB tests in which ME 8152 failed after 1,000 hours and ME 8161 by 3,000. The ME 8152 EaB result seems very low (11% of original at 1,000 Hours) and ME 8152 did much better than RM 8403 in the tensile impact test.

507. The Series H results were, as I have found, with the new stabiliser package for RM 8403 i.e. 1,300 ppm Tinuvin 783. These showed greatly improved results. But the comparison did not include a ZN.

508. There was, therefore, nothing in the subsequent results which, in my judgement, lent justification to the statement.

509. I am, however, wholly unpersuaded that Kingspan (in the person of Mr Rusk or Mr Rusk, on the advice of Dr McDaid) would not have purchased Borecene had the doubling statement, not been made or that it was a substantial cause of the purchase. Further, the import of doubling the lifetime of ME 8152 is unclear without knowing what was taken as the original lifetime and, whatever exactly it signified, and the sentence, which was part of an explanation for how the 1999 Letter of Conformity came to be signed, cannot have been understood as meaning that the expected lifetime for Borecene was other than as stated in the recommendation contained in the earlier and operative part of the email. It would not have mattered to Kingspan if the historical information had been left out.

510. Accordingly if the misrepresentation issue is governed by English law, Kingspan's misrepresentation claim against the contracting party under the Misrepresentation Act is not made out. I did not understand it to be suggested that, if that was so, a claim against the contracting party in tort would fare any better. (It may be that a claim in tort would have avoided the need to show that Borealis intended, as opposed to foresaw, reliance on the content of the email of 18 November but I have found the necessary intention established). As will be apparent hereafter I have come to the conclusion that the contracting party was Borealis Denmark.

Misrepresentation claim against Borealis UK

511. My conclusions make it unnecessary to determine whether, in English law, any claim for misrepresentation would be available against both Borealis Denmark and Borealis UK or only against the former. A single paragraph of the Reply alleges that Borealis UK assumed a duty not to make negligent misstatements of which it was in breach. It is Kingspan's case that if, as I have found, the contracts were with Borealis Denmark, it nevertheless has a tortious claim against Borealis UK.

512. In order for Kingspan to have such a claim it would be necessary to establish that Borealis UK, the commercial agent, must (applying an objective test by reference to what passed between the parties) be held to have assumed a personal responsibility for the statements made and that Kingspan reasonably relied on that assumption of responsibility: **Williams v Natural Life Health Foods** [1998] 1 WLR 830 at 835 G-H.

513. I am not satisfied that Borealis UK must be taken to have assumed a responsibility of its own separate from that of its principal. Borealis UK was once, but was, at the material times, no longer, the contracting party. In **Gran Gelato Ltd v Richcliff Ltd** [1922] Ch 560 Sir Donald Nicholls V-C, as he then was, held that:

> *"in general, in a case where the principal himself owes a duty of care to the third party, the existence of a further duty of care owed by the agent to the third party is not necessary for the reasonable protection of the latter. Good reason, therefore, should exist before the law imposes a duty when the agent already owes to his principal a duty which covers the same ground and the principal is responsible to the third party for his agent's shortcomings. I do not think there is good reason for such a duty in normal conveyancing transactions".*

514. I do not regard this as a case where there is good reason to impose such a duty. The general rule, as expounded in *Bowstead* (19th Ed.) at 9 -116 and in **Gran Gelato** is that liability for negligent statements made on behalf of a disclosed principal rests on the principal and not the agent. There is nothing special about the position of Borealis UK as a commercial agent in the present case to give rise to a duty. The agent has no liability under the contract and it would be anomalous if that which could not be achieved in contract could, nevertheless, be achieved in tort. I do not regard it as a sufficient reason for imposing the duty that any claim against Borealis Denmark is subject to contractual limitations. If anything the fact that the imposition of a tortious duty would circumvent the limitations is a reason not to impose one.

515. That Borealis UK was the commercial agent of Borealis Denmark was apparent from the communications between the parties and the invoices. I do not regard anything said or done by Mr Wood as conveying that Borealis UK was assuming a personal responsibility as well as its principal or that Kingspan could reasonably so understand. Nor is it apparent that Kingspan reasonably relied on any such assumption.

516. If Borealis UK had been under a duty in tort it would have been necessary to examine whether it was negligent since, if Borealis Denmark was negligent, it does not inevitably follow that Borealis UK was as well. I do not propose to address this question.

THE CONTRACTUAL ARRANGEMENTS

517. The claimants began buying Borecene in September 2001 (an order for 24,750 Kg) and from January 2002 onwards bought in large quantities. Prior to then they had regularly (several loads a month) bought ZN grades of polymer in significant quantities (e.g. 24 tonne loads) mainly for the Glenamaddy site and for Tyrell. They received invoices for Borecene which contained terms and conditions. They purchased RM 8402 from January to November 2002 and then RM 7402 from the end of 2002 to September 2003: the details are at appendix 4 to Borealis' opening.

The parties to the contracts

Local company sales prior to 1 January 1999

518. According to Borealis sales of its products were made in this way. Prior to 1 January 1999 sales were made by the local sales company on its standard terms: see para 522 below. That company would itself purchase the material from the Borealis company which produced it. Thus in the UK buyers would purchase material from Borealis UK which would purchase from Borealis Norway or Borealis Sweden. It is common ground that until 1999 the claimants contracted with Borealis UK. The invoices contained Borealis UK's terms and conditions on the reverse.

Sales by the production unit direct – 1999 to 2000

519. During 1999 and 2000 sales were made on Borealis' terms (as a result of letters sent out in November 1998: see paras 523 – 526 below), which were the same for different countries, by the relevant production unit – Borealis Norway or Borealis Sweden - direct to customers. But the invoices were factored to Borealis Coordination Centre N.V (a Belgian company – hereafter "Borealis Belgium"). The effect of this was that the customer became the importer of the goods and had a significant administrative burden dealing with VAT reporting.

520. Kingspan does not accept that, so far as they were concerned, there was any change.

Sales by Borealis Denmark – 2001 onwards

521. Then from January 2001 sales were made by Borealis A/S i.e. Borealis Denmark on the uniform terms.

The terms – pre 1999

522. Borealis UK terms applicable prior to 1999 provided so far as relevant as follows:

"13 WARRANTY AND EXCLUSION

(A) ***The Seller warrants that the Goods will comply with Seller's standard specification for the Goods at the date of the contract. If any of the*** *Goods do not conform to that warranty the Seller will at its option:*

(i) replace the Goods found not to conform to the warranty; or

(ii) take such steps as the Seller deems necessary to make the Goods conform to the warranty or

(iii) take back those Goods found not to conform to the warranty and refund that part of the purchase price paid in respect of the Goods

Provided that performance of one of the above options (as limited by sub-clause E) below) shall constitute an entire discharge of the Seller's liability under this warranty.

(B) The foregoing warranty is conditional upon

(a) the Buyer giving written notice to the Seller of the alleged defect in the Goods such notice to be received by the Seller within seven days of the time when the Buyer discovers or ought to have discovered the defect and in any event within one year of the delivery of the Goods

(b) the Buyer affording the Seller a reasonable opportunity to inspect the Goods and if so requested by the Seller returning the allegedly defective Goods to the Seller's works carriage pre-paid for inspection to take place there and

(c) the Buyer making no further use of the Goods that are alleged to be defective after the date at which the Buyer discovers or ought to have discovered that they are defective

(d) the defective goods have been used, stored and maintained in accordance with general practice and the Goods not having been altered or repaired by any person other than the Seller or those authorised by the Seller

(e) the Seller being satisfied that the defect in the Goods was due to its defective workmanship or use of defective materials and without prejudice to the foregoing the Seller shall be under no liability for defects due to wear and tear or neglect or use of the Goods for any purposes other than those for which they are supplied

(f) the defective Goods not having been sold, let, hired or otherwise disposed of by the Buyer to a second or subsequent purchaser.

(C) ***Save as provided in sub-clause (A) hereof***

(i) All conditions and warranties whether express or implied by statute, common law or otherwise howsoever, as to the quality or fitness for any purpose of the goods or their correspondence with description are hereby expressly excluded to the fullest extent permitted by law, and

(ii) the Seller shall be under no liability for any loss or damage (whether direct, indirect or consequential) howsoever arising which may be suffered by the Buyer by reason of any defect of whatsoever kind in the goods

(D) Without prejudice to the generality of sub-clause (C) above all recommendations and advice given by or on behalf of the seller to the Buyer as to the methods of storing, applying or using the Goods, the purposes to which the Goods may be applied and the suitability of using the Goods in any manufacturing process or in conjunction with any other materials are given without liability on the part of the Seller its servants or agents.

(E) ***In any event the Seller's liability in respect of any defect in the Goods shall not exceed the purchase price of the Goods.***

(F) Nothing herein contained shall be construed as an attempt to exclude or limit the liability of the Seller in negligence for the death or injury to any person insofar as the same is prohibited by United Kingdom Statute" [Bold added]

The November 1998 letters

523. In **November 1998** Borealis sent to its customers a package of at least four letters. The first letter[60] provided as follows:

"Dear Business Partner

Re: Shared Service Centre & Direct Invoicing

Continuously striving to be a top performer in our processes to serve customers in the most original way, Borealis has decided to establish a Shared Service Centre (SSC) for managing the transaction processing of a major part of our financial administration. The new concept will go into effect on January 1 1999.

The SSC will be located in Woluwe, Belgium under the legal umbrella of the existing Borealis Coordination Center (BCC).

We are convinced that by centralising financial tasks, Borealis' personnel will be able to focus even more on core activities like production, logistics and sales and thus respond faster to your needs.

For the same reasons Borealis has decided to optimise its current invoicing process. This means that there will be a change from the re-invoicing principle through the local sales company to direct invoicing by the delivering production unit. *Settlements, however, will be done via the local BCC account as described in the attachment. As before, all the specific payment instructions will continue to be featured on our invoices.*

……..

Because of the integration of PCD[61] and the direct invoicing from our production units in different countries, we recognise the need for harmonising our General Terms and Conditions of Sale. You will find the revised document attached. Irrespective of the source of delivery, you will deal with a commercial partner who applies unified conditions with respect to commercial, insurance and legal matters. *We are confident that you will find the harmonised terms* ***to be even more customer oriented and simplified.***

[60] According to the evidence in the Balmoral trial there was a covering letter (see para 91) which is referred to in para 29 of Mr Webster's first statement but which is absent from the trial bundles.
[61] An Austrian producer recently acquired by Borealis.

> *If you have any questions or require further information, please do not hesitate to contact (name and contact information of your local credit controller[62]). Thank you"* [Bold added]

524. The second letter informed customers that from 1 January 1999 onwards Borealis' sales invoices would be factored to Borealis Belgium "*which will be the sole legal beneficiary of all collections*". This letter (i) asked customers to follow the payment instructions on the sales invoices and to quote invoice numbers as reference in all payments; (ii) indicated that the aim was to introduce direct debits as an alternative method; and (iii) invited customers to direct all payment related inquiries to Borealis Belgium.

525. The third letter related to the introduction of the Euro and informed customers that they could do business either in Euros or national currency. The fourth letter related to Year 2000. There was also attached (a) a form of acknowledgement of receipt and (b) Borealis' General Terms and Conditions.

526. Kingspan denies that it ever received these documents. No acknowledgement of receipt has been produced.

The letter of 11 December 1998

527. On 11 December Borealis UK sent Mr Rusk of Plashapes (as Titan was then called) a letter which was received on 14 December 1998 and which was seen by Mr Rusk. The letter, although appearing to be responsive to a communication from Kingspan, was in fact in standard form and was sent to many customers. It included the following:

> *"Dear Fred*
>
> *Re: Shared Service Centre*
>
> *Our recent mailing on the euro into our business practices (sic), the Year 2000 challenge and the establishment of a Shared Service Centre (SSC), have raised, especially for the latter, some concerns and remarks from your side.*
>
> *With the creation of a SSC, it is definitely not our aim to transfer costs, currently paid by Borealis, to you. Our customer service is always our first priority and we would therefore like to clarify the points of concern raised.*
>
> **Central invoicing:* ***Your local Borealis Sales Office will print and dispatch the invoices in the name of the supplying Borealis plant and continue to offer assistance on any issues relating to payments. Invoicing from different sites instead of invoicing through one local sales company necessitates your maintaining different supplier files****. The creation of one bank account reference for all the Borealis sites, will, however, soften the additional administrative effort. The planned second stage of the project will enable central invoicing, independent of local Sales Offices, thereby reducing the*

[62] The version disclosed by Borealis is a draft. The relevant contact information would have been specified for the particular customer.

temporary complexity introduced by the first phase, and establishing one invoicing and collecting entity.

.....

We hope that this letter answers your questions and concerns, if you require any additional information, please do not hesitate to contact us." [Bold added]

1999 - 2000

528. During 1999 and 2000 the invoices were, I assume, in the form described in paras 533 - 536 below, save that (i) the invoicer was Borealis Norway or Sweden, and (ii) the second page was different and provided for payment to Borealis Belgium[63]. The Borealis General Terms and Conditions were printed on the reverse of the invoice. I say that by way of assumption because that is what is apparent from the Balmoral judgment. There do not, however, appear to be any invoices from this period in the trial bundles. (There may, also, have been a short period during which, because of a software error, the words "Sales Office" appeared instead of Commercial Agent in respect of Balmoral UK: see para 100 of the *Balmoral* judgment).

529. Orders were sent to Borealis UK in Cheshire; but Kingspan must have made payment to Borealis Belgium.

The letter of 3 November 2000

530. On 3rd November 2000 Mr Wood of Borealis UK sent to Mr Rusk of Kingspan a letter on Borealis UK notepaper, which Mr Rusk received. This included the following:

"Borealis is committed to continuously improving Borealis' customer service. This is why we are establishing a single invoicing entity. Effective ***January 1 2001, all material delivered by Borealis, irrespective of production site, will be invoiced from Borealis A/S, the Danish parent company.***

…… In the future you will deal with only one supplier.

Our commercial, day-to-day contact is not affected by this change in invoicing….

I strongly believe that this change simplifies the administration at your end and is of mutual benefit to us..." [Bold added]

531. An attached document informed Kingspan that

" ***Effective January 1 2001, all deliveries of Borealis products, irrespective of the production site, will be invoiced to you by our group Danish sales company:***

Borealis A/S (address in Denmark given).

[63] Details may be found at para 100 of the Balmoral judgment.

For sales made on DDP[64] *terms Borealis A/S will be the importer of the goods in the country of sale and will be responsible for intrust reporting where applicable. As a consequence invoicing will include local VAT in all EU countries except Greece, Luxembourg and Ireland.*

Credit management and the collection process will remain administratively within the Borealis Group's financial Coordination Center in Belgium. Customer payments should be executed for credit of Borealis A/S directly to one of the following accounts [3 different accounts with ABN AMRO were specified according to the currency of payment]" [Bold added]

532. So far as Borealis was concerned, the seller from January 2001 onwards was Borealis Denmark. The 1999 - 2000 arrangement whereby the producing company's receivables were factored to Borealis Belgium ceased. Borealis Denmark purchased the product from the producing companies. The new arrangements are described in internal Borealis documentation regarding the "*Singles Sales Company (SSAC) Project*", which confirmed that Borealis Denmark would take ownership of Borecene from the selling site in "*one theoretical second before the material reached the customers. This means that Borealis is the importer. The SSAC will have VAT registration numbers in all European countries. Sales will generally be with local VAT*".

The invoices

533. The goods were all invoiced by Borealis to the relevant purchaser. Each invoice had three pages. The first page was headed "BOREALIS". It contained in a box, inter alia, the invoice number and date and the customer number. It also contained the VAT numbers of the customer and Borealis. The number entered for the latter was the VAT number of Borealis Denmark. The terms of delivery were "DDP" the relevant Kingspan unit. The country of origin was described as Norway and the place of dispatch was, in the majority of cases, specified as Great Britain. Beneath the total invoice figure to the left of the invoice appeared the following:

"Borealis A/S
C/o Borealis UK
Borealis House
Water Lane Wilmslow
SK9 5AR Cheshire
United Kingdom

VAT no GB732914044

This document is solely payable to Borealis A/S ... [address given] *...via Bank transfer to the account 40092550 at ABN AMRO (London)... for beneficiary Borealis A/S*

All sales are exclusively covered by Borealis General Terms and Conditions of Sale as printed on the last page.

[64] Delivery Duty Paid.

Please contact your local Borealis representative if you have any questions regarding this oc/invoice"

534. Beneath those words were, on the left hand side, the words "INVOICED BY" underneath which were Borealis A/S' name and address in Denmark together with its telephone, telex, fax and registration (both company and VAT) numbers. On the right hand side were the words "Commercial Agent" underneath which were Borealis UK's name and address, company registration number and telephone and fax details.

535. The second page provided that cheques were to be sent to Borealis c/o ABN Amro at an address in London. Remittance advices were to be sent to Borealis Belgium.

536. The last page contained the General Terms and Conditions of Sale. These included the following:

> *"These General Terms and Conditions of Sale (in the following "General Terms") together with the order confirmation shall in so far no (sic) other agreement regulating the issue has been concluded in writing apply to all products (in the following "Products") sold by the Borealis entity given in the front page (in the following "Borealis") to its customers (in the following "the Purchaser").*
>
> ….
>
> ***5. Product Liability***
>
> *Borealis shall only be liable for damage due to product liability according to mandatory rules of applicable law and thus the liability of Borealis shall be restricted in all respects as much as possible under such law.*
>
> ***6. Limitation of Liability***
>
> *6.1. Borealis does not assume any responsibility for Products being suitable for any particular purpose unless Borealis in writing has approved such suitability.*
>
> …..
>
> > *6.3. Borealis' accumulated liability, excluding product liability which is subject to clause 5.1 above, for whatever reason including but not limited to delays, defect and shortfall shall at the option of Borealis be limited to either an exchange of the defective Products for non-defective Products or a refund of the invoiced value of the said Products.*
>
> ***8. Applicable Law and Venue***
>
> *These General Terms shall be governed by the law of the country where Borealis is domiciled without recourse to the conflict of laws principles of such jurisdiction, and the parties shall accept the relevant commercial court as venue."*

Negotiations between the parties

537. Negotiations between the parties over the price payable by Kingspan for Borecene took place between Mr Fred Rusk of Kingspan and Mr Wood, Borealis' Rotomoulding Sales Manager. The terms on which it was proposed that Borecene would be sold to the Claimants were set out in Mr Wood's letter to Mr Rusk dated 12th October 2001: see para 293 above. That letter gave no indication that the prices he was quoting were subject to Kingspan's acceptance of Borealis' terms and conditions. Nor did it give any indication that any contracts for the purchase of Borecene would be subject to Danish law.

538. After the initial supply of RM 8402, Mr Rusk and Mr Wood had a number of meetings at which revised prices for RM 8402, and later RM 7402, were agreed, together with the volumes to be supplied. Borealis does not suggest that Mr Wood ever said that the prices he quoted were subject to purchase contracts which were subject to Borealis' terms and conditions. Once Mr Rusk and Mr Wood had agreed a price for Borecene, each of the 4 individual sites raised purchase orders. Those purchase orders were sent to Borealis UK's offices in Wilmslow, Cheshire. They referred to Borealis UK as the supplier. Delivery Notes gave the Sales Office as Borealis UK in Cheshire.

539. It is not disputed that Kingspan received, looked at and paid the numerous invoices.

540. On 26 April 2002 Mr Wood wrote to Mr Rusk, from Borealis UK's offices on Borealis UK paper, to inform him "*as a matter of courtesy*" about some changes that were underway within Borealis. He confirmed that he would continue to be the sales manager and primary contact within Borealis. The letter enclosed a contact list, on which each of the individuals listed was located in England and contactable through the Borealis UK office. The letter made no reference to Borealis UK being the selling agent for Borealis A/S. Kingspan rely on this as being, they say, completely contrary to any suggestion that Kingspan's contractual relationship, at that point, was not with Borealis UK but with Borealis Denmark.

Kingspan's submissions

541. Kingspan contends:

i) that throughout the period from Autumn 2001 onwards the contracting party remained Borealis UK;

ii) that the general terms and conditions were governed by English law. Accordingly, subject to the effect of clauses 6.1. and 6.3 of the General Terms, they included implied terms that the Borecene supplied was of satisfactory quality and reasonably fit for the purpose of making static oil tanks;

iii) that UCTA is nevertheless applicable because of the provisions of section 27 thereof;

iv) that the relevant contracts are not international supply contracts within the meaning of section 26 of the Unfair Contract Terms Act 1977 (UCTA);

v) that clauses 6.1 and 6.3 are unenforceable because they are unfair contract terms; and

vi) that, if Danish law applies, section 36 of the Danish Contract Law should be applied so as to invalidate the terms.

Who was the contracting party?

Kingspan's case

542. Kingspan contends that Borealis UK remained the contracting party for the following reasons. The letters of November 1998 were never received. The letter of 11 December 1998, which was received, does not specify a change of contracting party. It is concerned with invoicing. So is the letter of 3 November 2000, which refers to "*a single invoicing entity*" which is not to affect "*our commercial day-to-day contact*". Mr Rusk's evidence was that he discussed that letter with Mr Wood who said that it meant no change in the relationship.

543. So far as the invoices themselves are concerned, they do not expressly state that the claimants' contract is with Borealis Denmark or that the purchase agreements to which they relate are governed by Danish law. They required payment to be made to Borealis Denmark by payment into a bank account in London, with remittance advices to be sent to Borealis Belgium. Clause 8 of the general terms stated that the terms were governed by the law of the country where '*Borealis*' is domiciled. '*Borealis*' is defined in the introductory wording of the general terms as '*the Borealis entity given in the front page*.' Both Borealis UK and Borealis Denmark are referred to on the front page. The references to the place of dispatch being Great Britain, the fact that Borealis' VAT number is a GB VAT number, and the fact that payment is required to be made to a London bank together indicate that the relevant Borealis entity on the front page is Borealis UK. Further, Borealis' own position – see Borealis' "*Singles Sales Company Project"* document - was that it was making "*domestic sales*" and was invoicing the customer "*under a local domestic VAT regime*". In addition the contact address for Borealis Denmark is given as Borealis House, Water Lane, Wilmslow, Cheshire.

544. All these points, it is submitted, show that the country where Borealis is domiciled for the purpose of the relevant contract is the UK, and specifically England & Wales, such that the law of the latter (rather than Danish law) is applicable to the contract.

Were the letters of November 1998 received?

545. I am not persuaded that the letters of November 1998 were received. Mr Rusk was adamant that he did not receive them. Since, on his own evidence, he was not someone who addressed himself to the question as to which Borealis entity Kingspan was contracting with, it is possible that he received the letters but paid no attention to them; or that he has forgotten them; or that they were never shown to him (they are addressed "*Dear Business Partner*" or "*Dear Sirs*") and went unnoticed by whoever in fact received them. I think the probabilities are that neither he nor Kingspan received them or, at the lowest, that it is not shown that they did.

546. The evidence of despatch is not particularly strong. The letter was drafted by an Italian gentleman and the draft was emailed from Borealis' then head office in Copenhagen to 14 sales offices in Europe. Each office was then to print out copies and type out envelopes for sending to customers on their computer master data base. Mr Webster thought that despatch would have been by courier. Mr Wood gave evidence that he sent the letters to Kingspan amongst others; but I have some doubts as to his recollection of events well over a decade on; and I note that in his first witness statement he described in some detail his recollection of his involvement at the meeting on 2 and 3 December 2002, which, in fact, he did not attend. Mr Webster, who was then working in Copenhagen, never saw the actual signed letters with their addressees' names on. At most he ticked names off on a list in his notebook on the basis of information from Mr Wood. No such list has survived.

547. It seems to me unlikely that, if the letter had arrived, Mr Rusk would not have been shown it. No copy of it has been disclosed. No return of the acknowledgment of receipt has been produced.

548. By contrast the letter of 11 December 1998 was received, date stamped on receipt and disclosed. That letter with its statement that:

> *"Invoicing from different sites instead of invoicing through one local sales company necessitates your maintaining different supplier files. The creation of one bank account reference for all the Borealis sites, will, however, soften the additional administrative effort."*

would have been somewhat puzzling to anyone who had not received the November 1998 letter. It indicated that there were to be two different invoicers who would be the original suppliers. But, if the November 1998 letter was never received, I am not persuaded that it was made sufficiently apparent to Kingspan that their contractual partner (as opposed to the entity to whom payment should be made) had changed. What is not clear to me is whether and, if so, why Kingspan paid Borealis Belgium (as I assume but do not know that they did). I suspect that they will have done so because the invoices (which do not appear to be in the documentation) for this period directed them to do so.

1999 and 2000

549. The letter of 3 November 2000, which Mr Rusk did receive, informed the reasonable reader in his position that from 1 January 2001 Borealis Denmark was to be the single invoicing entity and the single Borealis supplier. Such a combination of roles was scarcely surprising. Prima facie the supplier and seller of the goods is the person who is to be paid and who submits the invoice calling for payment. It is, of course, possible for the seller to assign the price to another (as had previously been the case as between Borealis Norway/Sweden and Borealis Belgium). But the letter of 3 November 2000 makes no reference to any assignment or factoring.

550. Further its terms *("all material delivered by Borealis, irrespective of production site, will be invoiced from Borealis A/S"; "In the future you will deal with only one Borealis supplier"; "The major changes.."; "All deliveries ... will be invoiced to you by our group Danish sales company"; "For sales made on DDP terms, Borealis A/S will be the importer of the goods in the country of sale… invoicing will include local*

VAT"; "...the collection process will remain administratively within [Borealis Belgium]": "Customer payments should be executed for credit of Borealis A/S directly to one of the following accounts") are, in my view, only consistent with Borealis Denmark being the seller/supplier which is entitled to payment and is, therefore, invoicing the goods.

551. It is likely, as Mr Wood accepted, that Mr Wood said something to the effect that the day to day commercial relationship (i.e. the meetings and contact between him and Mr Rusk at which the commercial details – product, amount, delivery times, and price – were thrashed out) would not change. I do not accept that he said anything which represented that the changes outlined in the letter would not take effect.

552. Mr Rusk was well aware, as he accepted, that polymer suppliers contracted on standard terms and that Borealis was supplying Borecene on its conditions. He received and signed hundreds of invoices and knew that they had terms and conditions. He was also broadly aware that Borealis gave no warranty "*when we turned it into green tanks*". There is no battle of the forms. Kingspan did not have terms on its purchase orders. Borealis' invoices made plain on their face that all sales were exclusively governed by Borealis General Terms and Conditions as printed on the last page. Those terms are printed on a single page in clear and legible typescript. They were never objected to. Borealis Denmark was reasonably entitled to believe that they were accepted.

Incorporation under English law

553. In those circumstances I am quite satisfied that, as a matter of English law, those terms were incorporated into the contracts of sale which are the subject of these proceedings: see ***Circle Freight International Ltd v Medeast Gulf Exports Ltd*** [1988] 2 Lloyd's Rep 427 and the cases there cited. It does not appear from the evidence that anyone at Kingspan ever read or addressed their minds to the content of the invoices other than the amounts. But that does not alter the position. The test for incorporation is an objective one.

554. On its proper construction, particularly in the context of the November 2000 letter which explained what was to happen in 2001, the "*Borealis*" referred to in clause 8 and the seller under the contracts of sale is Borealis Denmark, being the "*Borealis entity given in the front page*".

555. I say that for these reasons. The price is "*Invoiced by*" Borealis A/S i.e. Borealis Denmark. The terms and conditions "*apply to all products... sold by the Borealis entity given in the front page*". "*Borealis*" in clause 8 thus refers to the Borealis entity which is the seller, and not the seller's commercial agent. The Borealis VAT number specified in the box giving Invoice details at the top right hand side, in what is a VAT invoice, is the VAT number of Borealis A/S. No Borealis UK VAT number is given. The document is described as "*solely payable to Borealis A/S*". Payment is to be by cheque sent to Borealis A/S – a circumstance entirely consistent with it being the seller and supplier and invoicer; but difficult to follow if it was a mere invoicer (whatever that is), when there was also a Commercial Agent (Borealis UK) and another entity (Borealis Belgium) to which remittance advices (but not payment) were

to be sent[65]. Borealis A/S is the only apparent candidate as principal of that Agent. Consistently with this Mr Rusk signed a Bonus Agreement dated 30 September 2003 between Kingspan GSO and Borealis Denmark.

556. Borealis A/S was domiciled in Denmark, where it was incorporated, and where its central management and control was to be found. The fact that an address was given for it in Cheshire "*C/o Borealis UK*" does not alter that. The use of those words was itself an indication that the address in Cheshire was not the address of Borealis A/S (as was in any event apparent from the fact that Borealis A/S' address in Denmark appeared at the foot of the invoice). Since Borealis UK was, and was expressed to be, the Commercial Agent of Borealis A/S, the use of its address as somewhere where communications could be sent, care of itself, was in no way inconsistent with Borealis A/S having a domicile in Denmark.

557. It follows from all of the above that the sale contracts were, under English law rules, subject to the law of Denmark.

558. It seems to me, however, that it is the law of Denmark which determines incorporation: as to which see paras 559 - 568 below.

Incorporation under Danish law

559. Kingspan submits that clause 8 was ineffective to make the contracts subject to Danish law because:

a) whether or not clause 8 has been validly incorporated is a matter of Danish law; and

b) under Danish law inadequate notice has been given of the clause 8 term.

560. As to (a), I accept that, since under Article 8 (1) of the Rome Convention the existence and validity of a contract, *or any term of it*, is to be determined by the law which would govern it under the Convention if the contract or term were valid, the applicable law is that of Denmark.

561. As to (b) Danish law in respect of incorporation is set out in the report of Mr Madsen, Kingspan's Danish law expert, as follows:

> *"A party which accepts the other party's standard terms is in principle bound by them irrespective of whether or not such a party actually knows their content in detail or fully understands their implications. Danish law contains an important exception to this rule, which states that, notwithstanding its acceptance of the standard terms as a whole, the adhering party is not bound by terms, which by virtue of their content, language or presentation are of such a character that it could not reasonably have expected them. The reason for this exception is the desire to avoid a party which uses standard terms taking undue advantage of its position by attempting to impose terms on the*

[65] Mr Rusk agreed that it accorded with common sense and general commercial practice that it is the seller who sends the buyer an invoice.

> *other party which that party would very unlikely have accepted had it been aware of them."*[66]

562. Kingspan contends that, if the effect of clause 8, incorporating Danish law, is to deprive them of (i) the ability to challenge clauses 6.1 and 6.3 and (ii) any free standing claim for misrepresentation, then the clause is of such a character that they could not reasonably have expected it. They were given no warning that the effect of this clause would result in their losing the protection they had enjoyed in English law under the Misrepresentation Act 1967 and the Unfair Contract Terms Act and that this was a situation which they could not reasonably have expected. Accordingly clause 8 is inapplicable and the contracts were governed by English law.

563. This was not a case foreshadowed in the pleadings or the witness statements. Had it been, there might well have been questions which Borealis would have wished to ask in cross-examination or in the examination of their own witnesses. In those circumstances I do not regard it as open to Kingspan to advance this point.

564. In any event, I do not accept that clause 8 is of such a character that the claimants could not reasonably have expected it. The fact that the contract was to be governed by the law of Borealis' domicile was apparent from a reading of the invoices and clause 8 itself. Kingspan could reasonably have expected Danish law to be a term of the contract. So far as the effect of the term is concerned, it does not seem to me material that Danish law differs from English law in that (a) it has no tort of misrepresentation and (b) section 36 of the Danish Contracts Act provides significantly lesser opportunity to invalidate limiting provisions. Any non English legal system could reasonably be expected to have different provisions so far as those topics are concerned. The differences between the two systems are not so egregious as to call for special notice. The absence of a tort of misrepresentation is of limited significance given that Danish law could give effect, in appropriate circumstances, to a representation as defining the contractual obligation. Further since, as appears in the paragraphs that follow, the contracts were international supply contracts UCTA was not applicable to them - whichever law applied.

565. Some reliance was placed by Kingspan on the fact that the new terms were commended to those affected by them. Thus the letters of November 1998, sent to customers in several different countries, referred to the terms as "*even more customer oriented and simplified*". As I have already held, it is not established that Kingspan received this letter and Kingspan says it did not. But, even if it did, this was not a statement about the comparative position under different local laws. It was the evidence of Mr Bierfreund, Borealis' Danish law expert, which I accept, that, in the case of sophisticated commercial entities, the Danish Court would not disapply a term providing for Danish law which was unambiguous, even if generalised statements were made comparing the new terms, and, in particular the new choice of law, favourably to the old. It would expect the party concerned to make the appropriate investigations. So would I.

---

[66] In this context there appears to be no material difference so far as presentation of the terms to the customer is concerned between Danish law and English law. As a matter of English law, a party seeking to rely on a term which involves the abrogation of a right given by statute must show that the term has been brought fairly and reasonably to the other's attention. See Chitty on Contracts at 12-008 to 12-015, particularly at 12-015.

566. I would add three observations. First, as no one from Kingspan addressed their mind to the content of the invoices other than the amount and the payee, no one addressed his/her mind to the impact of the terms and conditions or the identity of the contracting party. Mr Rusk's evidence was that he did not have a conscious thought as to whom he was dealing with – "*it was just Borealis*" via Bob Wood; and that "*never once during my whole time did I ever think that terms and conditions were anything to do with me*". About twice a year Mr Peter Johnston, the financial director of Kingspan was involved in authorising payment to Borealis Denmark in respect of Borecene, if Mr Rusk or Mr McNamee, Titan's financial controller, was not around. He did not consider the detail of the invoices or the terms and conditions and was not passed any other relevant correspondence. He regarded it as Mr Rusk's job to bring any issue about terms to the attention of senior managers.

567. Second, no one at the claimants appears to have had any awareness of the existence and ambit of UCTA.

568. Third, it would seem a somewhat curious result that pursuant to Danish law (the putative law of the contract) clause 8 should not be regarded as incorporated because the application of Danish law should be regarded as something that could not reasonably have been expected.

Section 27 of the Unfair Contract Terms Act 1977

569. Section 27 provides:

> *"27 Choice of law clauses.*
>
> *(1)* ....
>
> *(2) This Act has effect notwithstanding any contract term which applies or purports to apply the law of some country outside the United Kingdom, where (either or both)—(a) the term appears to the court ..... to have been imposed wholly or mainly for the purpose of enabling the party imposing it to evade the operation of this Act"*

570. There is no evidence worth the name that clause 8 of the General Terms, which applies the law of Denmark to the contracts, was imposed either wholly or mainly to evade the operation of the Act. The evidence of Mr Jan Lindh, who was in the late 1990s Vice President of the Group Finance Department and then Director of Financial Shared Services, was that Borealis chose the law and jurisdiction of the single selling party because it was a logical thing to do. I find this neither surprising nor unreasonable. Borealis was changing to a single contracting party supplying customers in different European countries. It made sense to adopt a single law and jurisdiction and to choose that of the seller and parent of the Group.

571. No evidence establishes that anyone at Borealis (in any of its forms) who was concerned with the implementation of the Single Sales Company project and the use of clause 8 had in mind the evasion of the Act (of which Mr Wood and Mr Webster were unaware and of which there is no evidence that Mr Lindh was aware). Nor is there any evidence that any such person thought that Borealis' terms were vulnerable to attack under UCTA 1977. I have not heard from the in-house lawyers who advised

on the terms. But I decline to infer from the absence of such evidence that clause 8 was included wholly or mainly in order to evade the operation of the Act.

572. In those circumstances it is not necessary to consider whether Borealis' terms should be regarded as "imposed".

573. If I had held that section 27 applied, it would have been open to Kingspan to seek to rely on section 3 but not, as it seems to me, section 6 since the terms implied by the Supply of Goods Act would not have been contract terms. Whether it could successfully do so would depend on whether the contracts of sale were international supply contracts.

Are the contracts of sale international supply contracts?

574. If, contrary to my view, the contracts are subject to the law of England or subject to the law of Denmark but subject to the Unfair Contract Terms Act 1977 because of section 27, it is necessary to consider whether they come within section 26 of UCTA, which provides:

"26. International supply contracts.

(1) The limits imposed by this Act on the extent to which a person may exclude or restrict liability by reference to a contract term do not apply to liability arising under such a contract as is described in subsection (3) below.

(2) The terms of such a contract are not subject to any requirement of reasonableness under section 3 or 4: and nothing in Part II of this Act shall require the incorporation of the terms of such a contract to be fair and reasonable for them to have effect.

(3) Subject to subsection (4), that description of contract is one whose characteristics are the following-

(a) either it is a contract of sale of goods or it is one under or in pursuance of which the possession or ownership of goods passes; and

(b) it is made by parties whose places of business (or, if they have none, habitual residences) are in the territories of different States (the Channel Islands and the Isle of Man being treated for this purpose as different States from the United Kingdom).

(4) A contract falls within subsection (3) above only if either-

(a) the goods in question are, at the time of the conclusion of the contract, in the course of carriage, or will be carried, from the territory of one State to the territory of another; or

(b) the acts constituting the offer and acceptance have been done in the territories of different States; or

(c) the contract provides for the goods to be delivered to the territory of a State other than that within whose territory those acts were done."

575. The contracts in question in the present case are contracts for the sale of goods made by parties (Borealis Denmark and one or other of the claimants) whose places of business are in the territories of different States. The critical question, therefore, is whether section 26 (4) is satisfied. In relation to 26 (4) (a) the question is not whether the goods in question had the characteristic specified at the time when property passed to the relevant claimant but whether they did so at the time of conclusion of the contract.

576. In the **Balmoral** case I said this:

> *"447. Section 26 (4) (a) requires the court to determine whether, at the moment of contract, the goods supplied under it were still in the course of carriage from the territory of one State to the territory of another. In* ***Amiri v BAE Systems*** *[2004] 1 All ER 385, Mance LJ, as he then was, observed that section 26 (4) was "open to the comment that it has not been fully worked out" and that it may have been thought that the classical types of international trading contract (c.i.f., f.o.b, etc) should be excluded without more. Even contracts such as those may not come within section 26 (4) (a), if it is given a literal construction. Take the case where there is a string of CIF sales and the last one is made when the vessel is within the territory of the State where the cargo is to be discharged. On one view the goods are not then in the course of carriage from one State to another. Such a view is inappropriate. In the example given the goods can be properly said to be in the course of carriage from one State to another, just as a passenger may be said to be in the course of carriage from London to Paris when the Eurostar stops at Lille.*
>
> *448 I am satisfied that I should regard the Borecene the subject of the invoices naming Great Britain as the "place of despatch" as goods which, when the contracts were concluded, were to be carried or were in the course of carriage from the territory of one State (i.e. Norway) to the territory of another. The course of business involved Borealis UK checking with Borealis Norway that the goods could be produced and then confirming the order to Balmoral. It would follow that the goods would not, when the contract was concluded, have been in the United Kingdom and were to be carried thither once they had been manufactured. The evidence before me does not indicate that Borealis' warehouses in the UK were anything other than transhipment centres or that Borecene ordered by Balmoral was supplied to them from stock which, at the time of the contract, was in store in the United Kingdom waiting for a purchaser."*

The decision in **Balmoral** was referred to without disapproval by the Court of Appeal in **Trident Turboprop (Dublin) Ltd v First Flight Couriers Ltd** [2010] QB 86 at 95.

577. The contracts for sale in **Balmoral** were contracts made between 1997 and 2002 with Borealis Norway or Borealis Sweden, as principal. In the present case the Borecene

purchased by the claimants was produced in Norway, which is identified as the "Country of Origin" on the invoices.

578. In his evidence in the present case Mr Wood gave similar evidence to that which he gave in the **Balmoral** trial. He, Mr Wood, would telephone regular customers about 6-8 weeks in advance to obtain "guestimates" of their material requirements. On the basis of those he would send a monthly forecast to the production planners, at the time based in Copenhagen. The claimants would submit purchase orders to Borealis UK about 1-2 months before required delivery and Borealis UK would send the request on to the production plant. If the order could be met one of Mr Wood's assistants would acknowledge receipt of the order and confirm by e-mail or fax delivery date/s, volume and packaging. If there was some problem, Mr Wood would telephone the client to let them know and make whatever alternative arrangements were required. When an order could be met material would be delivered direct from the production plant to the address on the purchase order together with a delivery note. An invoice would then be rendered.

579. I am satisfied from Mr Wood's evidence, as I was from his evidence in Balmoral, that the goods the subject of these proceedings were *at the time of the conclusion of the contracts* for their purchase goods which were to be carried from one State (Norway) to another (the United Kingdom or the Republic of Ireland).

580. Less clear is the route taken by the goods. Mr Wood's recollection was that delivery was for the most part direct: for the first two claimants shipping was from Norway to Belfast and for the last two from Norway to Dublin; but *occasionally* shipments were made from Norway to the east coast of the UK and then overland until shipment to Ireland. Mr Webster also referred to direct shipments, although he indicated that *some* product sometimes came through Great Britain "*through a UK transhipment centre of warehousing in Gainsborough and [would] then be dispatched out from that to the customer with the appropriate paperwork*". He said that the centre had a limited buffer stock. His understanding was that where the invoice was marked "*Place of despatch: Great Britain*" the Borecene had been supplied from the warehouse in Gainsborough. But it would be necessary to ask Mr Lindh.

581. Almost all of the invoices refer to Great Britain as the place of despatch. A few refer to the Netherlands or Germany. It may be that all the goods the subject of the former invoices came via Gainsborough, although the evidence of Mr Wood, Mr Webster and Mr Lindh, to the effect that the preponderance of deliveries were *direct* raises doubt as to whether this was always so. That does not, however, mean that the goods were in Great Britain when the contracts were made and Mr Wood's evidence, which was not challenged, is directly to the contrary. Mr Lindh explained that, if the place of despatch was recorded as Great Britain, the producing company would have been the importer, the goods would have been taken into the warehouse, and the sale by the producing company to Borealis Demark would occur "*one theoretical second*" before delivery to Kingspan. If the goods went direct, then Borealis Denmark would be the importer, under its VAT number, and property would pass to it before the goods came into the UK.

582. Accordingly the contracts are all international sales contracts so that the limits imposed by UCTA on the extent to which a person may exclude or restrict liability by reference to a contract term do not apply to liabilities arising under those contracts.

Trident Turboprop is also authority that, as a matter of English law, terms excluding liability for misrepresentation are, in such contracts, not subject to the requirement of reasonableness.

Unfair contract terms

583. If, however, I am wrong to conclude (a) that the contracts were governed by Danish law, (b) that they were international supply contracts and (c) that section 27 of UCTA has no application, it would be necessary to consider whether clauses 6.1.and 6.3 are unenforceable on the ground that they are unfair contract terms.

The requirements of reasonableness.

584. The relevant statutory provisions are as follows. Sections 3 and 6 provide:

"3 Liability arising in contract.

(1) This section applies as between contracting parties where one of them deals as consumer or on the other's written standard terms of business.

(2) As against that party, the other cannot by reference to any contract term —

(a) when himself in breach of contract, exclude or restrict any liability of his in respect of the breach; or

(b) claim to be entitled—

(i) to render a contractual performance substantially different from that which was reasonably expected of him, or

(ii) in respect of the whole or any part of his contractual obligation, to render no performance at all,

except in so far as (in any of the cases mentioned above in this subsection) the contract term satisfies the requirement of reasonableness.

6 Sale and hire-purchase

(2) As against a person dealing as consumer, liability for breach of the obligations arising from—

(a) section 13, 14 or 15 of the 1979 Act (seller's implied undertakings as to conformity of goods with description or sample, or as to their quality or fitness for a particular purpose);

....

cannot be excluded or restricted by reference to any contract term.

(3) As against a person dealing otherwise than as consumer, the liability specified in subsection (2) above can be excluded or restricted by reference to a contract term, but only in so far as the term satisfies the requirement of reasonableness."

585. Section 11 provides:

"11. The "reasonableness" test.

(1) In relation to a contract term, the requirement of reasonableness for the purposes of this Part of this Act, section 3 of the Misrepresentation Act 1967 and section 3 of the Misrepresentation Act (Northern Ireland) 1967 is that the term shall have been a fair and reasonable one to be included having regard to the circumstances which were, or ought reasonably to have been, known to or in the contemplation of the parties when the contract was made.

(2) In determining for the purposes of section 6 or 7 above whether a contract term satisfies the requirement of reasonableness, regard shall be had in particular to the matters specified in Schedule 2 to this Act; but this subsection does not prevent the court or arbitrator from holding, in accordance with any rule of law, that a term which purports to exclude or restrict any relevant liability is not a term of the contract.

……………

(4) Where by reference to a contract term or notice a person seeks to restrict liability to a specified sum of money, and the question arises (under this or any other Act) whether the term or notice satisfies the requirement of reasonableness, regard shall be had in particular (but without prejudice to subsection (2) above in the case of contract terms) to-

(a) the resources which he could expect to be available to him for the purpose of meeting the liability should it arise; and
(b) how far it was open to him to cover himself by insurance.

(5) It is for those claiming that a contract term or notice satisfies the requirement of reasonableness to show that it does."

Schedule 2 provides guidelines for the application of the reasonableness test.

586. Since English law is not applicable sections 13-15 of the 1979 Act do not apply and section 6 of UCTA is not engaged. But, since the contracts were on standard terms, section 3 is. The effect of clause 6.3 is that, if Borealis delivers Borecene which is defective, there is no claim for breach of any warranty of suitability for purpose unless Borealis has approved such suitability; and, in any event, liability for any

breach is limited to an exchange of defective for non-defective product (no longer possible) or the price. In **Balmoral** I held, obiter, that, on a fine balance, I was not satisfied that Borealis had established the reasonableness of the terms of Balmoral UK which were similar to the General Terms. Mr Allen submitted that that decision was wrong but that, in any event, the circumstances of the present case were not identical.

587. I do not propose to consider whether or not, if the reasonableness test requires to be satisfied, it has been. This would only become relevant if I am wrong in at least two respects. If I am, the point will have to be considered. Meanwhile I do not think it appropriate to make another obiter decision on the point. It should not be assumed from that that, if I had been minded to decide the point, I would have reached the same conclusion in this case as I did in **Balmoral**; or even that I would not have been persuaded that my decision in **Balmoral** was wrong.

Section 36 of the Danish Contracts Act

588. Section 36 of the *Danish Contracts Act* provides:

> "*(1) A contract may be modified or set aside, in whole or in part, if it would be unreasonable or at variance with the principles of good faith to enforce it. The same applies to other legal acts.*
>
> *(2) In making a decision under subsection (1) hereof regard shall be had to the circumstances existing at the time the contract was concluded, the terms of the contract and subsequent circumstances."*

589. It is common ground between the parties' experts – Mr Madsen for Kingspan and Mr Bierfreund for Borealis – that the Danish courts would be very reluctant to interfere with commercial agreements of this type. Although the word "*unreasonable*" is used, and although the section gives the court a wide discretion, in the exercise of which the court can take account of whatever it thinks relevant including the loss suffered by the innocent party and the effect of any limitation of liability, the experts agree that, in the case of a commercial contract, a claimant would in practice be likely to have to show that the clause was grossly unfair. There are very few commercial contract cases in which section 36 has been successfully invoked. The experts were only aware of two examples which were on markedly different facts which appear to amount to gross unfairness. By contrast there are several cases where the section has been unsuccessfully invoked. I note, however, that Danish courts are not bound by the doctrine of precedent and that section 36 was described by Mr Madsen as a "*dynamic standard*" which evolved all the time.

590. Kingspan contends that the provisions of paragraphs 6.1. and 6.3. were, under an English law contract, terms that needed but failed to satisfy the requirements of reasonableness if they were to be enforced; that if the effect of incorporating Danish law would be that the terms were enforceable, it was necessary to draw this directly to Kingspan's attention, which was not done; and that, in those circumstances, it was unreasonable to give effect to them.

591. I am wholly unpersuaded (the onus of proof being – as the experts agree – on Kingspan) that it would be unreasonable, let alone contrary to the principles of good faith, to enforce the contracts in accordance with their terms or that I should modify or

set them aside on that account. The contracts were commercial agreements made between large commercial concerns with substantial bargaining power. Mr Rusk expected raw material suppliers to supply on their standard terms and conditions as was widespread practice in the industry. The terms on which Borealis was prepared to do business were plain to see and referred to and contained in every invoice. They were never objected to. The limitations on liability contained in the contracts were advantageous to Borealis; but that was not without benefit to Kingspan since an inability to limit would be likely to increase prices. Borealis could reasonably expect the courts to give effect to those terms, subject to any applicable statutory constraint. In fact, since the contracts are international supply contracts, they would not have been subject to the requirements of reasonableness. I note also that GSP itself had terms and conditions which purported to exclude liability for any loss of profit or for consequential or special loss or damage (cl 5) and any express or implied conditions, warranty or statement as to the quality of the goods or their fitness for purpose.

Claims in misrepresentation – which law applies?

592. Insofar as any representations were made by or on behalf of Borealis Denmark, with whom the contracts were made, and if English law applied to the issue of recovery for misrepresentation, the claimants could rely on (a) section 2 of the Misrepresentation Act and (b) the tort of negligent misstatement, subject to the impact, if any, of clause 6 of the terms. Insofar as any representations were made by Borealis UK, section 2 is inapplicable because Borealis UK was not the contracting party and the claimants could only rely on negligent misstatement if they could establish an assumption of responsibility by Borealis UK which, in my judgement, they cannot.

593. Danish law, to which the contracts are subject, does not have a doctrine of misrepresentation or a tort of negligent misstatement. (The position is or may be different if there is fraud but that is not alleged). But it allows the court to take into account a much wider range of factors than are permissible in English law, in determining whether goods supplied are conforming. These may include, but are not limited to, what English law would characterise as misrepresentations. Such misrepresentations may establish what is required if the goods are to be regarded as conforming to the contract.

594. It is, therefore, necessary to determine (a) what law governs the question whether the claimants have any claim in misrepresentation, negligent misstatement or the like; and (b) if the answer is English law, what is the effect of clause 6 on any claim in misrepresentation or negligent misstatement.

The governing law

595. Part III of the *Private International Law (Miscellaneous Provisions) Act 1995,* which governs choice of law in the case of tort or delict, provides as follows:

> **"11 (2) *Choice of applicable law: the general rule***
>
> *(1) The general rule is that the applicable law is the law of the country in which the events constituting the tort or delict in question occur.*

> *(2) Where elements of those events occur in different countries, the applicable law under the general rule is to be taken as being–*
>
> *(a) ...*
>
> *(b) ...*
>
> *(c) in any other case, the law of the country in which the most significant element or elements of those events occurred.*

596. In the present case the elements constituting the tort or delict include the following:

a) the making of the representations relied on;

b) the publication of the representations to the relevant representatives of Kingspan – Mr Gregg and Dr McDaid;

c) the reliance by them on those representations insofar as they did so;

d) the defects in the Borecene which allegedly rendered the representations false; and

e) the resultant loss and damage.

597. Of these the making of the representations contained in the promotional material may be said to have occurred in the places where they were printed and from which they were sent. It is not clear to me where they were printed but they appear to have been sent from Cheshire. Representations in the letter of conformity and the email of 18 November 2001 were made in the places from which they were sent to Kingspan. The letters of conformity were sent by Mr Rehn in Finland to Dr McDaid. The 18 November email was, I presume, sent by Ms Fatnes from Norway. Elements (b) and (c) occurred in Northern Ireland. (It is not suggested that the law of Northern Ireland differs in any way from that of England). The defects, if there were any, arose in Norway but their effect was only significant upon the delivery of the product in Northern Ireland or Eire. The loss and damage may be said to have been suffered in the UK and Eire where the claimants had to make payments by way of reparation and where their loss of profits arose. In my view the most significant element is the reliance on the misrepresentations and the second most significant element is the communication to the representees. These took place in Northern Ireland. Accordingly the general rule would make English the proper law.

598. **Section 12** of the 1995 Act provides;

> ***"12 Choice of applicable law: displacement of general rule***
>
> *(1) If it appears, in all the circumstances, from a comparison of–*
>
> *(a) the significance of the factors which connect a tort or delict with the country whose law would be the applicable law under the general rule; and*

> (b) *the significance of any factors connecting the tort or delict with another country,*
>
> *that it is substantially more appropriate for the applicable law for determining the issues arising in the case, or any of those issues, to be the law of the other country, the general rule is displaced and the applicable law for determining those issues or that issue (as the case may be) is the law of that other country.*
>
> (2) *The factors that may be taken into account as connecting a tort or delict with a country for the purposes of this section include, in particular, factors relating to the parties, to any of the events which constitute the tort or delict in question or to any of the circumstances or consequences of those events*."

Kingspan's submissions

599. Kingspan submits that it is inappropriate to displace the law of England, which has a misrepresentation/misstatement doctrine, in favour of the law of Denmark, which does not. The claimants are incorporated in Northern Ireland and Eire. The defendants acted though Borealis UK, an English company. The representations were made and relied on in the UK. They induced the purchase of material which was never made in nor shipped from Denmark. None of the events giving rise to the claim for misrepresentation occurred in Denmark. Clause 8 referred only to the General Terms being governed by the law of Borealis' domicile, when it could easily have specified that the relationship and/or any pre-contractual representations should be so governed. There is nothing novel in applying different laws in relation to different although related causes of action: **Base Metal Trading Ltd v Shamurin** [2005] 1 WLR 1157. In that case claims by a company against a director in respect of speculative trading were treated by the Court of Appeal (without enthusiasm and under the law prior to the 1995 Act) as subject to Russian law in respect of the tortious, and Guernsey law in respect of the equitable, claims.

Borealis' submissions

600. Borealis submits that it is the law of Denmark which should govern both misrepresentation and contract. The parties have agreed that the terms are to be governed by that law. The terms themselves, and in particular para 6.4 (which deals with Borealis' accumulated liability "*for whatever reason*"), display an intention that the entirety of the parties' relations with regard to the contracts should be governed by the terms. It would be irrational for a contractual claim e.g. for lack of fitness for purpose to be subject to Danish law and governed by the terms when a parallel claim based on a misrepresentation (express or implied) or a negligent misstatement as to fitness was subject to a different law. The appropriate law governing the effect, if any, of any misrepresentation, must be the law of the contract itself.

Authority

601. This topic was considered by Aikens J, as he then was, in **Trafigura Beheer BV v Kookmin Bank Co** [2006] EWHC 1450. The facts were of some complexity. Trafigura sold oil to Huron. When it arrived in South Korea it was discharged without

production of the bills of lading against a letter of indemnity and later released to Huron. Trafigura received payment under a letter of credit from Kookmin, through a London advising bank, on presentation by Trafigura of documents including the letter of indemnity. Kookmin asked for the original bills. Trafigura's Singapore office took the original bills, thought to be discrepant, to the Singapore office of the vessel's managers and obtained new bills which conformed to the Letter of Credit but which were endorsed "*voyage accomplished null and void*". These were forwarded to Kookmin. Kookmin claimed in Korea that Trafigura's acts in discharging the cargo to Huron, returning the original bills and clausing the substitute bills were tortious under Korean law because they deprived Kookmin of any security interest and any right to claim against the carrier. Trafigura started proceedings in England against Kookmin for a declaration that it did not undertake or represent that it would provide the original bills of lading to Kookmin. Kookmin challenged the jurisdiction of the court. That challenge failed. A preliminary issue was then ordered as to the law governing Kookmin's tortious claim against Trafigura.

602. Aikens J held that the country in which the most significant element(s) of the events constituting the tort occurred was Singapore and that, therefore, under the general rule, Singapore law should determine the issues relating to the claim. But he went on to hold that one of the factors "*relating to the parties*" was the law that the parties had expressly or impliedly chosen to govern their pre-existing contractual relationship which was said to give rise to the events constituting the alleged tort. The most important connecting factor in the case was the letter of credit contract which was governed by English law. The second was the fact that all but one of the relevant contractual relationships between the parties were governed by English law. (These were, in addition to the letter of credit contract, the relationship between the issuing bank and the advising bank; the underlying sale contract; the charterparty - but not the first set of Bills; and the Letter of Indemnity). It was, therefore substantially more appropriate for the law of England to be the applicable law governing the relationship between Trafigura and Kookmin for issues relating to tort. He concluded that:

> *"when the law governing all the contractual relationships between the relevant parties concerned with the Sale Contract and its financing is English law, it would seem bizarre to hold that the applicable law to determine issues arising in relation to Kookmin's tort claim against Trafigura should be the law of another country viz Singapore"*

603. A similar question arose in an earlier decision of Aikens J in **Dornoch Ltd v The Mauritius Union Assurance Co Ltd** [2005] EWHC 1887 (Comm); upheld in the Court of Appeal [2006] EWCA Civ 1887. In that case the first defendant ("MUA") underwrote Bankers' Blanket insurance for the Mauritius Commercial Bank Ltd ("MCB") under 3 policies each of which was expressly governed by the law of Mauritius. Each of the policies was 100% reinsured in the London Market. MCB discovered a large scale fraud and claimed in Mauritius under the insurance policies. The claimants in the London action, who were reinsurers, sought declarations that one of the reinsurance policies had been validly avoided on account of, inter alia, material misrepresentations together with damages for misrepresentation and for deceit or negligent misstatement. The misrepresentations were said to have been made by both MUA and MCB in the proposal form for the Reinsurance which MCB had completed.

604. Aikens J held that there was a good arguable case that the proper law of the Reinsurance was English. One of the issues that he had to decide was as to the proper law of the torts alleged to have been committed by MCB. Aikens J decided that the most significant element of those torts occurred in England and that on that basis the proper law of the torts was English Law.

605. He then said this (obiter):

> "*Mr Kealey appeared to rely on the fact that, as he submitted, the Excess Reinsurance is governed by Mauritius law, in order to invoke section 12 of PILA. I have held, provisionally, that the proper law of the Excess Reinsurance is English law. But even if I had concluded to the contrary, that would not help him establish that the law applicable to <u>the torts of MCB</u> is Mauritius law. I must confess to finding section 12(1) difficult to apply in relation to all the issues in this case. Section 12(1) appears to say that, if having considered the matter under section 11(2(c) you decide that the most significant elements lead to the proper law of the tort being that of country A, nevertheless, you may consider it more appropriate to conclude that the proper law should be that of country B ("the other country"), bearing in mind the factors set out in section 12(2). But, in this case at least, that involves considering precisely the same elements all over again. In any event, the fact that the fraudulent misrepresentations were made in order to induce the Reinsurers to enter the Excess Reinsurance whose proper law would be that of Mauritius seems to me to have nothing to do with the tort in question. Nor does the fact that the Proposal Form was also used in respect of the direct insurance, which is governed by Mauritius law.*"

606. There appears to me a degree of tension between Aikens J's approach in the two cases. In **Trafigura** the fact that most of the relevant contractual relationships were governed by English law led to the law applicable to the tort claim being that of England. In **Dornoch** the fact that the only relevant contract was (on an obiter assumption) governed by Mauritian law and that the fraudulent representations were made in order to induce the Reinsurers to enter into it was said to have nothing to do with MCB's tort. Mr Fenwick submitted that the material difference between the two cases was that, in the former, English law had been chosen to cover most of the contracts and the events said to give rise to liability had arisen out of the matrix of those contractual relationships, whereas in **Dornoch**, the representations preceded the contract. I am not convinced that that makes the relevant events materially less connected to the contract. It is, however, important to note that the tort under consideration in **Dornoch** was the tort of MCB, which had no contractual relationship with the Reinsurers. Accordingly there never was any agreement on its part on the application of Mauritian law for any purpose.

607. Both parties relied upon the unsatisfactory consequences which they submitted would result from rejection of their submissions. Kingspan submitted that, if English law applied, it would be open to a party to make false statements to induce a contract and avoid all liability for them by making the contract subject to the law of a country which did not recognise claims for misrepresentations. Borealis submitted that, if Kingspan was right, terms such as the General Terms would effectively be worthless because it would always be open to a buyer to bring a parallel tortious claim (e.g. on

the basis of an express or implied representation of fitness) which would not be available under the law which the parties had agreed should apply to the contract.

608. I do not regard these arguments from consequences as compelling in either direction.

609. As to that of Kingspan, even if the choice of a foreign law precludes a claim for what in English law would be a misrepresentation, the misrepresentation may not be without effect under the alternative legal system. Even if it is, it is not obviously unacceptable for a choice of law clause to preclude a claim for misrepresentation or its equivalent. I note that Article 12 of Rome 2, which was not in force at the relevant time[67] provides:

> *"Article 12*
>
> *Culpa in contrahendo*
>
> *1. The law applicable to a non-contractual obligation arising out of dealings prior to the conclusion of a contract, regardless of whether the contract was actually concluded or not, shall be the law that applies to the contract or that would have been applicable to it had it been entered into."*

610. As to that of Borealis, if, as Kingspan contends, English law applies to the misrepresentation issue, the terms would not be worthless since they would limit contractual claims. Whether any representation was made would depend on the facts; and, any failure of the terms to embrace tort claims would be a failure of drafting. Nor is it self-evident that an ability to bring an English law misrepresentation claim in respect of a foreign law contract would be unacceptable.

Conclusion

611. I have come to the conclusion that it is substantially more appropriate to disapply the general rule and treat the questions of misrepresentation and misstatement as subject to the law of Denmark. The contracts in question are international supply contracts made between business enterprises of comparable bargaining power. They are not consumer contracts nor were the claimants tricked into entering into them on these terms. When businesses of that character reach agreement they do so as a result of statements and/or assurances made and contractual documentation sent, exchanged or signed. English law distinguishes between (a) factual statements that induce the contracts; (b) contractual terms; and (c) collateral undertakings, and applies different rules to each. Other laws have different classifications. Given that these statements, terms and undertakings are the product of the same process which leads to the eventual contract it is substantially more appropriate, in my judgement, for the law of the contract, chosen by the parties, to apply to all of them.

612. This is particularly so because of the closeness of the connection between misrepresentation (a claim which is probably to be regarded as an action founded on

[67] It applies to "*events giving rise to damage which occur after its entry into force*" which was, for present purposes, January 11th 2009. The Regulation (S35/243) has direct effect within the territories of the Union save Denmark.

tort - as was *"the present view"* (obiter) of the Court of Appeal in ***Laws & Ors v Lloyd's*** [2003] EWCA Civ 1887 [92]) and contract. Misrepresentation, despite its tortious and statutory parentage, is, in a sense, part of, or at least appurtenant to, the law of contract since it may give rise to a right to rescission. Under Rome 1 the existence and validity of a contract is determined by the applicable law (Article 8) as are the various ways of extinguishing obligations (Article 10 (1) (d)). A claim for rescission would be governed by the applicable law i.e., here, the law of the contract chosen by the parties: see *Briggs, Agreements on Jurisdiction and Choice of Law*, 10.31. I accept Borealis' submission that the position should be no different when the remedy sought – for the same cause of action - is damages rather than rescission, especially when, under section 2 (2) of the 1967 Act the Court can award damages in lieu of rescission. Since contracts are consensual arrangements in which the parties are entitled to choose any municipal law they wish to govern their relationship it makes sense for the law which they have chosen also to govern the consequences (if any) of any misrepresentations which are said to have induced it. I note that in ***Trident Turboprop*** the Court of Appeal interpreted the expression "*liability arising under such a contract*" in section 26 (1) of UCTA as extending both to liability for damages for misrepresentation and to the right of the injured party to rescind where that appears possible.

613. Such a conclusion also seems to me to reflect commercial sense. Borealis, as was apparent, was intending there to be a single seller to customers in several different jurisdictions under terms which incorporated Danish law, under which contractual restrictions could not be circumvented by the invocation of closely-related tortious claims. It was on that basis that Borealis' prices would be fixed. To treat the misrepresentation claim as subject to English, and the contract subject to Danish, law would allow the claimants to effect that circumvention, whilst retaining the benefit of prices fixed on a different assumption.

614. Each invoice provided "*All sales are exclusively governed by these general terms and conditions*". There two ways of looking at this clause (a) that it is concerned only with claims under the contract of sale; (b) that it relates to contractual claims and extra contractual claims for statements which led to the contract so that a misrepresentation claim, which would otherwise be subject to English law was, by agreement, to be governed by Danish. I am not persuaded that that phrase is sufficient to constitute an agreement that any English law claim for extra contractual liability in misrepresentation, which would not otherwise be governed by Danish law, should be so governed. If the draftsman was thinking in terms of Danish law, he did not need to address the question of extra contractual liability since there is none. If he was thinking in terms of extra contractual liability under some other law, he did not say so in terms and, if such liability was, in effect, to be excluded, some more specific wording was needed.

615. Lastly, if Kingspan be right, it can avoid all the limitation provisions of the contracts by suing on a parallel tortious claim in which an implied term of fitness for purpose is deployed as an implied representation to that effect. That would emasculate the terms. This seems to me an additional reason for disapplying the general rule.

Effect of clause 6 if English law applies

616. If, however, English law applies to the issue of negligent misrepresentation/negligent misstatement, I do not regard clause 6 as excluding or limiting liability for it. Although the approach of the courts to the construction of exemption clauses may not be as strict as it once was – see **Bikam OOD Central Investment Group SA v Adria Cable SARL** [2012] EWHC 621 (Comm) - the wording needs to make it clear that it applies to representations (i.e. false statements inducing a contract) as well as the contract itself. In the present case the reference in clause 6.3 to "*accumulated liability arising for whatever reason"* is readily applicable to contractual liability which may arise because of one or more of the three reasons - "*delays, defect and shortfall*" - to which the clause refers, as well as, for example, delivery to the wrong place. It is not, in my judgement, apparent that it relates to misrepresentations; the more so when it would have been relatively simple for the draftsman to make clear - as he did in the case of Borealis UK's terms[68] – that liability for misrepresentation was being excluded and limited. But he did not.

What Danish law amounts to

617. Danish law incorporates Part 1 of the UN Convention on *Contracts for the International Sale of Goods 1980* ("CISG"). Articles 35 and 36 provide as follows:

*"**Section II. Conformity of the goods and third-party claims***

Article 35

(1) The seller must deliver goods which are of the quantity, quality and description required by the contract and which are contained or packaged in the manner required by the contract.

(2) Except where the parties have agreed otherwise, the goods do not conform with the contract unless they:

(a) are fit for the purposes for which goods of the same description would ordinarily be used;

(b) are fit for any particular purpose expressly or impliedly made known to the seller at the time of the conclusion of the contract, except where the circumstances show that the buyer did not rely, or that it was unreasonable for him to rely, on the seller's skill and judgement;

(c) possess the qualities of goods which the seller has held out to the buyer as a sample or model;

(d) are contained or packaged in the manner usual for such goods or, where there is no such manner, in a manner adequate to preserve and protect the goods.

---

[68] Clause 13 (D): "*...all recommendations and advice given by or on behalf of the seller to the Buyer as to the methods of storing applying or using the Goods, the purposes to which the Goods may be applied and the suitability of using the Goods in any manufacturing process or in conjunction with any other materials are given without liability on the part of the Seller its servants or agents".*

(3) The seller is not liable under subparagraphs (a) to (d) of the preceding paragraph for any lack of conformity of the goods if, at the time of the conclusion of the contract, the buyer knew or could not have been unaware of such lack of conformity.

Article 36

(1) The seller is liable in accordance with the contract and this Convention for any lack of conformity which exists at the time when the risk passes to the buyer, even though the lack of conformity becomes apparent only after that time.

(2) The seller is also liable for any lack of conformity which occurs after the time indicated in the preceding paragraph and which is due to a breach of any of his obligations, including a breach of any guarantee that for a period of time the goods will remain fit for their ordinary purpose or for some particular purpose or will retain specified qualities or characteristics."

618. **Article 8** provides:

"(1) For the purposes of this Convention statements made by and other conduct of a party are to be interpreted according to his intent where the other party knew or could not have been unaware what that intent was.

(2) If the preceding paragraph is not applicable, statements made by and other conduct of a party are to be interpreted according to the understanding that a reasonable person of the same kind as the other party would have had in the same circumstances.

(3) In determining the intent of a party or the understanding a reasonable person would have had, due consideration is to be given to all relevant circumstances of the case including the negotiations, any practices which the parties have established between themselves, usages and any subsequent conduct of the parties."

619. Danish law's approach to contractual interpretation is markedly different to that of English law. The evidence of the experts appears to me to support the following propositions:

a) the Court is concerned to discover the common *subjective* intention of the parties;

b) but where the intent of a party is not known or apparent to the other, his statements are to be given an objective interpretation;

c) when determining the intent of the parties as to the quality and description of the goods required by the contract the court is not confined to looking at what the contractual documentation says. The

Court is entitled to take into account anything which it regards as assisting it in deciding what the contract required. As Mr Bierfreund, Borealis' expert, put it "*everything is of possible relevance*". This includes what was said and done by the parties before the contract and after it was concluded;

d) Danish law has no independent principle of misrepresentation. But a representation is potentially relevant to an assessment of whether the goods were conforming. For instance, a sufficiently precise or specific statement in a brochure, as opposed to a general appraisal, could form part of the contractual obligation; and

e) if there is an ambiguity in the contract it will be construed against the draftsman.

Article 35 (1)

Kingspan's case

620. In reliance on proposition (d) in the previous paragraph Kingspan submits that, if and insofar as the representations which they relied on were made and were, in respect of the goods supplied, false, there was a breach of Article 35 (1) because Borealis failed, in those respects, to deliver goods of the quality and description required by the contract. It is not necessary for this purpose to establish reliance on the seller's skill and judgement, nor is it relevant whether or not the buyer knew of the lack of conformity, because Article 35 (1) is not subject to Article 35 (2) (b) or Article 35 (3).

Borealis' case

621. Borealis submits that Article 35 (1) is concerned, like section 14 (2) of the Sale of Goods Act 1979, with whether the goods had a reasonable quality e.g. that they were properly manufactured, uniform in quality and compliant with any contractual specification as to properties. No case of breach of any such requirements was advanced.

622. Further the contractual obligation as to quality cannot require the goods to possess a quality which the buyer knows before the contract that they do not possess, as Mr Madsen confirmed in his oral evidence and as I accept.

623. It was not open to Kingspan to advance a claim relying on representations since it had never been pleaded that the representations formed part of the terms of the contracts. The case was floated for the first time in the cross examination of Mr Bierfreund.

Discussion

624. I have already held that it is not open to Kingspan to rely on representations which they have never pleaded, or which they have withdrawn, to support a claim in misrepresentation. Nor can they do so by treating them as terms or requirements of the Danish law contract.

625. I also do not regard it as open to Kingspan to rely on what was and remains pleaded as a misrepresentation as constituting a term or requirement of the Danish law contracts,

particularly when, in the absence of a pleaded case as to implied term or terms or requirements arising from what was pleaded as a representation, (a) the reports did not deal with the extent to which any of the representations relied on might constitute, to Danish law eyes, provisions of the contract (and only touched on the question of implied terms, very briefly); and (b) Borealis did not cross examine Kingspan's expert on the issue. In portraying what English law would treat as a representation as a requirement of a Danish law contract, Kingspan are in truth alleging that the requirement is a term of the contracts. Even if there is some distinction between a term and a requirement it seems to me that the latter requires to be pleaded.

626. In any event, as I have already held, the misrepresentation claim is not well founded; and it does not, in my judgement, fare any better as a basis for identifying the terms or requirements of the contracts under Danish Law. The very general representations in the brochures that Borecene was suitable for rotomoulding oil tanks and that Borecene was "*fully UV stabilised*" or "*UV stabilised*" are not apt to import a specific contractual term as to the timespan of UV resistance of the polymer, and cannot be used to import an obligation which would be more extensive than what Kingspan was specifically told about weatherability in the email of 18 November 2001. The recommendation expressed in that email cannot, in my judgement, be converted into some form of contractual promise. If that is too English law a view, and the contracts should be regarded as incorporating an undertaking that Borecene RM 8402 was a polymer which could reasonably be expected by Ms Fatnes to have the characteristics described, there was no breach thereof. Nor can the representation in that email, as part of the description of how the August 1999 letter of conformity came to be written, about doubling the lifetime of the ME 8152 grades, be regarded as a contractual term.

627. The letter of conformity and the email of 18 November 2001 are expressions of opinions, not contractual terms. Their potential significance lies in what they show Borealis to have known as to the particular purpose for which Kingspan wanted their product.

628. The contracts themselves contain no express terms as to quality and I do not regard them as containing any terms, relevant for present purposes, other than those that may be imported by virtue of Article 35 (2).

Article 35 (2)   Kingspan's case

629. Borealis knew that the Borecene it sold to Kingspan would be used by them to rotomould tanks for the storage of oil including storage outdoors. Accordingly, subject to the caveats in Articles 35 (2) (b) and 35 (3) there was a breach of the terms of the contract, if the Borecene delivered was not fit for that purpose.

630. Where the buyer makes known to the seller that the goods being purchased should last for a particular period of time the goods will not conform with the contract if they do not last for that period of time. Borealis was aware that the claimants (other than ROM) guaranteed their tanks for up to 10 years. Accordingly, subject to the caveat in Article 35 (2) (b), there was a breach if the Borecene delivered was not fit for the purpose of being used by them for the manufacture of rotomoulded tanks for the storage of oil that would last 10 years in Europe.

631. Further, in appropriate circumstances, Article 35 (2) imposes an obligation to ensure that the goods delivered complied with any applicable requirements of the country of destination. Such an obligation will be imposed if the buyer has informed the seller of the requirements, or if there are special circumstances which would give the seller knowledge of the requirements. Such requirements may include rules and standards adopted by private entities such as trade associations.

632. Borealis was well aware that the OFTEC Standard was the only polyethylene oil tank standard in force at the relevant time and what it required. Accordingly it was a term of the contracts that the Borecene supplied would meet the material requirements of the OFTEC Standard and that it was fit for the purpose of manufacturing rotomoulded tanks which themselves met those requirements. Insofar as Borecene did not meet those material requirements and was not fit for that purpose Borealis was in breach.

633. The caveat in Article 35 (2) (b) - *"where the circumstances show that the buyer did not rely, or that it was unreasonable for him to rely, on the seller's skill and judgment"* - is inapplicable. The claimants did rely on Borealis' skill and judgement in relation to the properties of Borecene, which was a new polymer, and it was entirely reasonable of them to do so.

634. Article 35 (3) is not applicable. Kingspan did not know (nor was the position that it could not have been unaware) that Borecene was unfit for the purpose of manufacturing by rotomoulding oil tanks which complied with the OFTEC requirements and which would last for 10 years in Europe. If they had known that they would not have purchased Borecene at all.

635. Clause 6.1 of Borealis Denmark's terms does not exclude the obligation imposed by Article 35 (1); nor does it exclude the obligation under Article 35 (2) to provide goods fit for purpose if Borealis gave written approval for such purpose. Clause 6.1. provides:

> "*Borealis does not assume any responsibility for Products being suitable for any particular purpose unless Borealis in writing has approved such suitability.*

Borealis did approve in writing the suitability of Borecene for the manufacture by rotomoulding of external oil tanks in various brochures, guides and data sheets.

Discussion

636. Articles 35 (2), (a) and (b), resemble (but do not replicate) the requirements of satisfactory quality and fitness for purpose laid down in sections 14 (2) and (3) of the Sale of Goods Act 1979. Article 35 (2) (a) is a general requirement of reasonable quality in terms of fitness for the sort of uses which goods of the same description are ordinarily used as opposed to fitness for any particular purpose which is the subject of Article 35 (2) (b). In the present context it required Borecene to be fit for the purpose of making tanks, including oil tanks, by rotomoulding; but not for any particular longevity.

637. I do not regard any breach of Article 35(2) (a) as established. Borecene was fit for rotomoulding to make, inter alia, external oil tanks. Borecene has been used successfully in many different applications including outdoor applications.

638. I am satisfied, subject to certain caveats that the propositions set out in paras 630 (goods lasting for period of time) and 631 (compliance with applicable requirements) above are broadly accurate. They are vouched by Mr Bierfreund's evidence in the former case and Mr Madsen and Mr Bierfreund's reports in the latter.

639. The caveats are these. First, it is necessary to recognize that the goods under consideration and the time frame contemplated by the OFTEC Standard related to the moulded tank and not to the raw material. Any requirement of fitness for purpose would have, therefore, to be a requirement that Borecene *could* be used to produce a product that would last for the required period; not that any tanks made from Borecene *would* do so. Whether tanks would last for the requisite period would depend on a range of factors which are within the control of the manufacturer and not the material supplier: e.g. design, stress, shot weight, wall thickness, wall thickness variation, pigmentation type, concentration, and method of incorporation, blending methods, processes and processing skill.

640. Second, the case as argued before me was conducted on the basis that, although the error in the conversion of 900 Klys was spotted, the OFTEC Standard was not amended. If the November 2002 document disclosed during the trial and to which my attention was directed after its conclusion was a final, operative version the Standard was amended to tally with prEN13341. However, on that hypothesis it would not, in my judgement, be reasonable for Kingspan to rely on Borealis to ensure that Borecene would pass the 34 GJ/m^2 EaB test in a WOM, which is not the same thing as surviving that degree of irradiation outside the WOM, when Kingspan had (a) asked for a letter of conformity relating to that figure; (b) not been given it; and (c) not renewed the request. Further, the evidence does not reveal the extent to which, and when, Borealis (or Kingspan) was apprised of any change in the OFTEC Standard.

641. I am also satisfied that Borealis knew:

a) that the Borecene it sold to Kingspan would be used by them to manufacture rotomoulded tanks for the external storage of oil;

b) that Kingspan wanted the tanks made by them from Borecene to last for up to 10 years outside in Europe; and

c) that the claimants also wanted such tanks to comply with the OFTEC standard.

642. Item a) is common ground.

643. As to b), the evidence of Messrs Webster, Wood and Halvorsen was to the effect that they were aware that tank manufacturers often sold tanks with 10 year guarantees. Ms Fatnes stated in the Balmoral litigation that Borealis was aware at various levels that Balmoral and other tanks manufacturers were selling with 10 year guarantees. Borealis did not, however, regard itself as giving a corresponding warranty.

644. Further Borealis' testing was based on a requirement to last 10 years. Ms Fatnes' minutes of a meeting in June 1996 contain the statement "*Need normally to estimate properties to approx 10 years*": (see para 191 above). One of the actions specified by Ms Fatnes in the minutes of a meeting on 11 August 1997 was "*Check UV level needed to guarantee 10 years lifetime*": see para 189 above. An internal document of October 2002 in relation to Balmoral, which asked whether 8402 was fit for purpose, set out the question which Mr Joyce of Balmoral had asked "*UV – is the amount we add sufficient for 10 years outside in Europe?"*: see para 337 above. The prEN13341 standard referred to 10 years in its earliest version.

645. As to c), Borealis was aware that Kingspan needed to comply with the OFTEC requirements, not because of any statutory requirement but because they were members of OFTEC and, as such, required to comply with its standards, and because Kingspan sought to sell their tanks as OFTEC approved. Borealis was a member of OFTEC. Ms Fatnes had been aware of the existence of OFTEC since 1995. In August 1999 she sent Mr Rehn a copy of the OFTEC Standard when asking him to issue a letter of conformity to the claimants. Mr Webster understood that "*anybody who wanted to use the material in their tanks had to get their tanks approved by OFTEC*". However, the extent to which Borealis was aware of any change to the Standard in November 2002 was not the subject of any evidence.

The essential term

646. In my judgement in Balmoral I said this:

> *"148 Borealis were the makers of Borecene, and therefore in the best position to know its intrinsic properties, both chemical and mechanical. They had, as their literature made clear, a sizeable research and technology department. The intrinsic properties of Borecene were within their sphere of expertise. They were also well equipped to perform a range of standardised tests on samples of their products, and customers would be entitled to assume that when Borealis' literature set out the results of those tests it did so accurately.*
>
> *149 Borealis had the facility to make and did make relatively simple rotomouldings, usually in the shape of small boxes, with conventional moulding equipment. This enabled them to make several copies of a standard product for testing purposes. (QUB did the same). Mr Halvorsen carried out extensive rotomoulding trials of Borecene, experimenting with changes of temperatures, ratios, machine settings etc. The boxes were then sent to the laboratory for testing of mechanical properties. But Borealis were not professional rotomoulders, let alone conversant with the particular way in which Balmoral designed, manufactured and tested oil tanks. That was within Balmoral's sphere of expertise.*
>
> *150 In those circumstances Balmoral, in ordering Borecene,* ***reasonably relied on Borealis to supply a polymer whose properties made it reasonably suitable for the purpose of making green oil tanks by rotomoulding, in the sense that it was capable of being used to make consistently satisfactory tanks.*** *By "satisfactory" I mean tanks which would last for a reasonable minimum period of time in ordinary use. The ten year period covered by*

Balmoral's warranty (and that of many other tank manufacturers) is a suitable measure.

151 ***Borealis would not have fulfilled that obligation if Borecene's properties were such that, whatever reasonable adjustment was made to Balmoral's processing parameters, including grade of pigment and method of pigment incorporation, satisfactory green oil tanks could not be made despite an adequate design of tank.*** *Nor would Borealis have fulfilled its obligation if the possibility of a need for an adjustment of processing parameters would not have occurred to a competent rotomoulder, or if such a rotomoulder would not be able to discover by reasonable endeavours what change of parameter was needed.*

152 But Balmoral could not reasonably rely on Borealis in respect of design or rotomoulding both of which were within its sphere of expertise. As to the former, it is the job of the rotomoulder to design his tanks. A polyethylene supplier is not responsible for failings in design. As to the latter, a competent rotomoulder would realise that all raw material products are different, that a new product may perform in ways that differ from the way in which products that he has previously used have performed, and may react differently to the same pigments and methods of pigment incorporation as he has used before, as well as to different ones. One of the reasons why raw material suppliers supply samples of their products free of charge before purchases begin is in order to enable manufacturers to gauge the suitability of the supplier's material for the particular purpose for which they intend to use it, i.e. by using their own moulds, pigments, blending methods, and processing parameters. This happened in the case of MFR 3 and MFR 6." [Bold added]

647. Although the language of Article 35 is different, I regard the view that I expressed in those paragraphs, substituting "the claimants" for Balmoral, as prima facie applicable in the present case, subject, however, to:

a) whether it was reasonable, on the facts of the present case, for Kingspan to rely on Borecene having any particular UV resistance;

b) whether the 10 year period which I chose as representing a reasonable period of time is appropriate; and

c) the impact of clauses 6.1. and 6.3.

648. Mr David Allen QC for Borealis submitted that it was wrong to import any term or condition into the contracts for the supply of Borecene, *the raw material*, which required or related to a 10 year lifetime of *the rotomoulded tank*. The two are quite different. Borealis was responsible for the former but played no part in the production of the latter. In particular they had, as I accept, no control over any of the large number of factors e.g. design, pigmentation and processing, which contribute to the life span of a processed tank. Mr Madsen, Kingspan's Danish law expert agreed that, in general, applying Article 35 (2) (b) a buyer could not rely on the seller of a raw material in respect of the performance of a product made from that material.

649. Further, Mr Allen submitted, no standard required *the raw material* to last for any given length of time. In respect of the *moulded tank*, there was no 10 year requirement either in law or in the OFTEC standard. The prEN13341 standard did refer (originally) to 10 years but it was not in force at any relevant time and the tanks were not sold as being CEN certified. Both the OFTEC and the prEN13341 standards required samples from the moulded tank. The 10 year period guaranteed by many rotomoulders was originally selected for purely commercial reasons, to meet the competition then presented by steel tank manufacturers. It was not based on any technical assessment. Although three of the claimants gave a 10 year guarantee, one gave only a five year one. That itself had been increased from a previous 1 year, apparently for commercial reasons, although the precise rationale, if there was one, is unclear. The claimants now only offer a guarantee of 2 years on their single skinned tanks. None of the claimants sought a 10 year guarantee from Borealis.

650. Whilst I see the force of those submissions, I do not agree with them. If there is to be any requirement that Borecene be suitable for rotomoulding oil tanks based on the requirements of Kingspan it cannot sensibly lack any temporal connotation or be unrelated to Kingspan's known requirements.

651. In my view, Article 35 (2) required Borecene to be capable of being used to make consistently satisfactory tanks which, if suitably pigmented, would last for 10 years. Borealis knew that Kingspan wanted tanks made by them from Borecene to last 10 years and, like other manufacturers had, save in the case of Rom, where the guarantee was for five years, given 10 year guarantees. 10 years was also the period which corresponds in Northern Europe to the 900 kilolangleys referred to in the OFTEC Standard (if you assume average irradiance of 90 Klys a years) or to the 34 GJ/m² which the prEN standard had, by late 2001, adopted, (if you assume average irradiance of 80 Kly per year).

652. I have considered whether it is inappropriate, in the light of the recommendation in the 18 November email that green pigment be used for a lifetime of 10 years and black for anything above, to take 10 years as the reasonable period for green tanks, given that 10 years is the upper limit of the recommendation and a prudent manufacturer might well think it appropriate to cater for a period above 10 years to allow a margin for error. I remain, however of the view that 10 years is the appropriate period, having regard not only to the terms of the recommendation but also to the matters set out in para 644 above.

653. I have also considered whether the fact that the email of 18 December was a recommendation based on an expectation that tanks with green pigment could last 10 years means that Kingspan cannot have relied, or reasonably relied, on Borecene having, as a matter of contract, the capability to which I refer. In my judgement it can. I do not regard the expression of that expectation as inconsistent with an undertaking that Borecene with green pigment was capable of being used to make tanks which would last 10 years. Indeed, if it was incapable of being so used, whatever reasonable adjustment was made, the expectation was unfounded.

654. It would not, in my judgement, be unreasonable for Kingspan to rely on Borecene fulfilling this criterion. If the material did not do so, Kingspan was unaware of that.

655. I emphasize, however, that the obligation is for Borecene to be *capable* of being used to manufacture oil tanks which would last for this period and is subject to the observations which I made in paras 151 and 152 of the Balmoral judgment (and I would also add the words "*or designs*" after "*processing parameters*" in para 151). The obligation is not to underwrite the claimants' guarantees. Nor is it an undertaking that every tank made from Borecene will last for that period. Borealis cannot be responsible for matters which are not within its control such as poor or inadequate design, inappropriate or insufficient pigment, unsuitable processing, inadequate wall thickness or excessive thickness variation. Nor do the contracts require that Borecene must be fit for use in exactly the same way as other polymers. New polymers with different characteristics (e.g. lower viscosity) may require a change of one or more of the factors within Kingspan's control which affect how long a tank will last. Further the fact that material is required to be reasonably suitable does not mean that it was bound to be suitable without any change of processing or design.

656. I do not regard that analysis as imposing some unreasonable burden on Kingspan and rotomoulders in their position because it would involve Kingspan in testing of its own rotomoulded products. Dr Botkin underscored the importance of rotomoulders doing their own weathering tests on their products. He recommended such testing and would not condone a complete absence of it. In 1999 Mr Schindler sent Kingspan a document entitled "*UV stability of Dowlex for Rotational Moulding*" which said that careful selection of pigment and thicker walls would improve UV resistance. The 2000 Dowlex letter of conformity expressed the need for testing on pigmented samples. I have little doubt that Mr Schindler advised PDC of the need for tests on rotomoulded products to establish the efficacy of any green pigment used in augmenting performance. In fact no testing was carried out by Kingspan on the effect of pigments, although Kingspan knew that the pigment used could significantly affect the strength of the material.

657. Further Kingspan had PDC as well-qualified technical advisers, whose function it was, inter alia, (i) to address the question of OFTEC compliance and the suitability of any material for any given design; (ii) to consider what testing was needed or appropriate; and (iii) to advise the producing factories, where necessary, about processing. The evidence of Mr Crowe (the managing director of Kingspan Environmental & Renewables Limited) was that he would have expected PDC to take all reasonable steps to be satisfied that Kingspan could use a material successfully before advising that the material could be bought and to carry out (or see that there had been carried out) whatever tests were necessary to ensure that the raw material could be used satisfactorily with Kingspan's designs. Kingspan had much greater expertise in tank design and rotomoulding than Borealis.

658. I do not, however, accept that, in order to determine whether there is a breach of any required standard of fitness for purpose it is essential for the Court to be able to specify the threshold measurements (e.g. of viscosity, crystallinity, molecular weight distribution) which the material had to satisfy.

The effect of clause 6.1.

659. Clause 6.1 does not exclude the obligation imposed by Article 35 (1) or 35 (2) (a). It does exclude that of Article 35 (2) unless Borealis approved the suitability of Borecene for any particular purpose.

660. Kingspan submits that Borealis approved the suitability of Borecene for the manufacture of external oil tanks in the following ways:

a) The 2000 Rotational Moulding brochure stated that the applications for RM8402 included "*underground, oil, water tanks*".[69]

b) The 2000 Borecene Processing Guide also identified oil tanks as one of the applications for RM8402.

c) Borealis' June 2000 Borecene Processing Guide listed oil tanks as one of the applications for which RM8402 was suitable.

d) Mr Webster's written evidence was that "*By 2000/2001… the RM8402 and RM7402 datasheets did include reference to 'Static Oil tanks' as an Application*."

e) From at least May 2001 until August 2003, Borealis' datasheets for RM8402 represented that RM8402 was suitable for the rotational moulding of "*Static Oil Tanks*".

f) Borealis' Borecene brochure included a photograph of one of Kingspan's own tanks, thus clearly indicating that Borecene was suitable for the manufacture of Kingspan's tanks.

661. Borealis submits that the use of *"approved"* in clause 6.1. signifies a specific confirmation of suitability in writing in response to a request from a particular customer and not a general statement of broad application in circumstances where there may be numerous types of product, manufacturers, and designs. The purpose of clause 6.1, they submit, is to allow Borealis the opportunity to consider whether it is prepared to accept responsibility for the suitability of its products for any customer's particular purpose. Borealis dealt with a wide range of customers who made a wide range of products, whose qualities would be heavily dependent on matters beyond their control. The different designs and processes used would mean that Borecene (or any other raw material) would perform differently in different products (even products of the same broad type, such as oil tanks). It would not have been feasible for Borealis to give blanket approval to a whole category of customers making a range of different products of the same type.

662. Kingspan submits that there is no requirement for approval to be given specifically to themselves and at their request, and that, in any event, the inclusion of one of their tanks in one of the brochures shows that it was given. Nor is there any requirement for an acceptance of liability.

663. I do not accept that a clause 6.1 approval has to be a specific approval in response to a request from a particular customer. The clause does not say that (and any ambiguity should be construed against Borealis). I can see no reason why a brochure or advertisement which makes a general statement that a product is suitable for making something cannot qualify.

---

[69] In his oral evidence Mr Webster confirmed that this included oil tanks, whether or not underground.

664. But the approvals referred to in para 660 are general approvals of the suitability of Borecene for rotomoulding external oil tanks. They are not in terms approvals of the suitability of Borecene to make tanks with any particular degree of weather resistance or longevity. I do not regard them as approvals of the suitability of Borecene for making tanks which would last for 10 years. Kingspan's requests for a letter of conformity and for information to give to KIWA recognised the need for more specific information.

665. Kingspan requested and received a letter of conformity relating to 22 GJ/m^2. Although that letter is a statement of expectation, I regard it as an approval of the suitability of Borecene (in the sense described in paragraphs 150 -152 of the *Balmoral* judgment) for making tanks with the degree of weatherability specified. In saying that weatherability of 22 GJ/m^2 was expected (and by implication that there were reasonable grounds for that expectation) Borealis was approving the suitability of Borecene as a polymer capable of being used to make tanks with that degree of resistance.

666. Kingspan asked for but did not receive a letter of conformity in respect of 34 GJ/m^2. What they did receive was the email of 18 November 2001 with its recommendation that, for 10 years' life coloured pigment such as green should be used, and black for more than 10 years. That seems to me an approval of the suitability of Borecene RM 8402 as capable of being used to make green tanks which would last 10 years.

Unreasonableness

667. It was not, in my judgement, unreasonable for Kingspan to rely on Borecene RM 8402's suitability in the sense that I have described (a) for making tanks with a weatherability of 22 GJ/m^2 and (b) for making tanks with a 10 year lifetime if an appropriate coloured pigment was used. The fact that Kingspan had carried out trials on Borecene which did not include UV testing and knew that Borealis had not carried out the tests required by the OFTEC Standard, did not, in my judgement, disentitle them from relying on Borealis in these respects. Borealis was not professing ignorance of any basis on which to give the letter of conformity or to send the email. On the contrary the latter referred to a lot of data available since the former.

668. Accordingly Borealis' contractual obligation in respect of RM 8402 must be regarded as an obligation to provide a product which, suitably pigmented, was capable of being used to make, consistently, tanks with a 10 year lifetime. The same applies to RM 7402.

Limitation of Liability Clause 6.3.

669. In any event, clause 6.3. applies so as to limit Borealis' liability for whatever reason – a phrase which must include any liability under the contract – to an exchange of defective product for non-defective product (no longer possible) or a refund of the invoiced value.

BREACH

General

670. The relevant question is not whether ZN was better than Borecene; nor whether Borecene differed from ZN e.g. by having a lower average molecular weight; but whether Borecene was defective in a manner that rendered it unfit for purpose, and whether that deficiency was the, or an, effective cause of the increased failure of Borecene made tanks. The onus of proof in relation to both matters rests with Kingspan.

671. Professor Marshall, who has a worldwide reputation in relation to polymers and their failures, told me that he simply could not say why Borecene made tanks had cracked in such numbers. I accept the submission of Mr Allen that one reason for the difficulty lies in the form of Kingspan's case, which has been, in large measure, to assume that some characteristic of Borecene is responsible for the increase in failures and to seek to discern some difference between Borecene and ZN material which could be regarded either as, or as illustrative of, the defect.

672. By contrast Borealis has referred to a number of factors – e.g. deficiencies in design, method of pigment incorporation, and failures in processing and quality control - as possible causes of the increased failure, and submitted that one or more of them are the likely causes. At the lowest, it is submitted, they cannot be ruled out as possible causes and, if they cannot, Kingspan has not proved its case.

673. The validity of the latter submission is a question of degree. If Kingspan establishes that factor X is likely to be the, or an, effective cause of the increase, the claim is not to be defeated because there are other possible causes. But the existence of a number of possible causes may mean that it is not possible to conclude which is/are the likely one(s).

674. For understandable reasons Kingspan has sought to eliminate individual factors or combinations of factors (e.g. design, processing, design and processing, pigment, pigment and stress without UV exposure) as possible causes in order to establish that inadequate resistance to UV was the cause. This is a perfectly legitimate approach subject to the caveat that focussing on a single factor will be inappropriate if more than one factor is the cause and that the combination of factors chosen for analysis may be the wrong combination.

675. In order to determine whether or not Borealis was in breach of its obligations and with what result, and to try to answer (if that be possible) what Professor Marshall regarded as an unanswerable question, it seems to me necessary to examine:

a) the nature, extent and pattern of failure of Borecene made tanks;

b) the significance to be attributed to that pattern and other features of the case;

c) the technical evidence from several disciplines; and

d) the extent to which actions or omissions of Kingspan may have contributed to the increased failures;

in order to determine, in the light of all that material, whether it shows that Borecene was incapable of being used to make, consistently, tanks with a 10 year lifetime and whether it is that which has caused the preponderance of Borecene failures.[70]

676. Insofar as tests reveal a distinction or difference between Borecene and ZN it is necessary to determine whether the difference (a) can and (b) does explain (as the more likely explanation) the higher incidence of Borecene failures. I also agree with the observation of Professor Malatesta that the cause of the cracking is unlikely to be determinable upon the basis of the technicalities of one discipline alone.

The pattern of failure

677. During the period 2002-2003 the Kingspan companies produced something of the order of 115,000 green oil tanks at their four production units.

678. Prior to 2002 failure rates had been historically very low. For example, at Banbridge only 0.19% of 2002 and 0.34% of 2004 production of tanks from ZN was reported as having failed within 6 years of production.

679. From as early as August 2003 tanks made from Borecene began to fail in service in large numbers. The most common mode of failure was the cracking of tank walls. As a result heating oil (kerosene) leaked where the failure occurred below the level of the fuel. The number of tanks that have failed was, as at March 2011 (the time of the joint statement of Ms Hasselll, Kingspan's expert and Mr Jensen, Borealis') of the order of 25,000. The corollary of that statistic is that well over 85,000 tanks made from Borecene had not been the subject of complaint despite the lapse of some 8 years.

680. In respect of each of the production sites (which had separate workforces and were separately run):

a) the number of failures as a percentage of production rose dramatically in respect of tanks which were 3 or 4 years old and then tailed off in respect of subsequent years for each factory: compare Marshall 1 figures 5-8 with figure 1 and see Mr Jensen's Report of 10 March 2011 Tables 1-4;

b) the reported failure rate of tanks made from Borecene far exceeded (by at least 7 times) the reported failure rates for ZN: see figure 15 in Hasselll 1 at para 691 below;

c) although the volume of Borecene used and the dates on which it was used varied, there was an exact correlation between the use of Borecene and the higher reported failure rates: see figures 1-8 in Hasselll's report of 13.4.11;

d) this greatly increased rate applied whatever shape or type of single skin tanks was being considered: see figures 18-23 of the latter report;

[70] This is a lengthy exercise: the conclusions begin at para 973 below.

e) there was a markedly different accumulation of failures (for Borecene and non Borecene) according to factory. Thus, Mr Jensen's 10.3.11 report reveals that, as at the date of its compilation, 9.04 % of RM 8402 single tanks had failed at Carrickmacross compared with 48.14% at Portadown and 33.86% at Banbridge: see, also Table 11. There are differences in failure rate for the same or similar designs with the same material as between different factories l (Nugent 1 figures 23, 54 & 55, 73 & 81); and

f) there was a significant difference in the rate of failure (for Borecene and non Borecene) according to design. See Jensen 10.3.11 Tables 9 and 10; Marshall 1 figure 71; Marshall 2 figure 5. In general the more angular the design the greater the likelihood of failure.[71]

681. Both sides rely on the pattern of failure as supportive of their respective cases.

Kingspan's submissions

682. Kingspan relies on the following:

a) It is common ground that the tank failures would not have occurred if Borecene had not been used. (Borealis' case is that the failures arose from Kingspan's failure to use Borecene properly);

b) The features set out in the penultimate paragraph show that wherever, however, and whenever tanks were made with Borecene, they failed in far higher numbers than those made from ZN material, which had been perfectly satisfactory;

c) This, it is said, points almost inescapably to the conclusion that Borecene is not suitable for the making of oil tanks for external use; rather than that there was some failure in design or in the method of production;

d) Consistently with this Borealis has adduced no evidence that Borecene can be used satisfactorily to rotomould oil tanks. They have not identified customers to whom they have sold Borecene who have used it for that purpose without serious problems. Not only has Kingspan suffered severe problems at each of their four sites, there is evidence that Kingspan Environmental in Poland has experienced precisely similar problems despite having new moulds in October 2000: (as to which see para 747 (e)). Further, although the causes of failure have not been the subject of this trial other users i.e. Balmoral, Carbery and Rotec have all reported problems. Anyone who made tanks from Borecene appears to have suffered failures in unacceptably high numbers; and

[71] Kingspan's designs have changed over the years since the 1990s, often by the reduction of wall thickness and an increasing degree of angularity.

e) The absence of evidence of satisfactory use supports the conclusion that it was not possible to rotomould oil tanks for external use using Borecene.

Borealis' submissions

683. Borealis, for its part, contends:

i) that Kingspan's line of reasoning is defective;

ii) that the features upon which it relies, together with others, lead to the opposite conclusion namely that the failures are attributable to generic problems of design and processing, in particular its failure to optimise its processes and properly to check on its product and its wall thicknesses (as well as failing to give proper instructions as to shot weight) when using a new material with lower viscosity at zero shear; and

iii) that the submissions in d) and e) above ignore, as they do, the incidence of the burden of proof as well as the fact that the Balmoral failures were never attributed to UV weakness. Kingspan has not presented any empirical evidence to the effect that it was impossible, whatever adjustment was made, to make satisfactory tanks.

684. As it happens it was Mr Halvorsen's evidence that before RM 8402 and RM 7402 were introduced he and a few colleagues carried out experiments with Borecene using some of the more complex moulds that Borealis had; and, although they had some difficulties in securing even wall thickness (it was necessary to change the rotation speed and ratio), they were able to make tanks with satisfactorily even wall thickness, as demonstrated by wall maps. I was invited to reject this evidence, which was not in his witness statement and not the subject of any documentary record, on the footing that, if it were true, it would have surfaced far earlier and been heavily relied on. However I regarded Mr Halvorsen as a witness of truth. I do not believe he has made this up.

685. As to the relevant features, the proposition underlying Kingspan's case is that there is something defective in Borecene as a material; not that individual batches were, for some reason, defective. (Ms Takacs carried out some testing of different batches and found no significant difference between them). This proposition does not fit, it is submitted, with a situation:

a) where something like 85,000 out of 115,000 tanks have *not* been reported as failing approximately eight years after manufacture (a situation described by Dr Botkin as "*surprising*");

b) where the failure rate has tailed off;

c) where failure rates vary dramatically from site to site, including as between Banbridge and Portadown, factories for which no significant under reporting is suggested; and

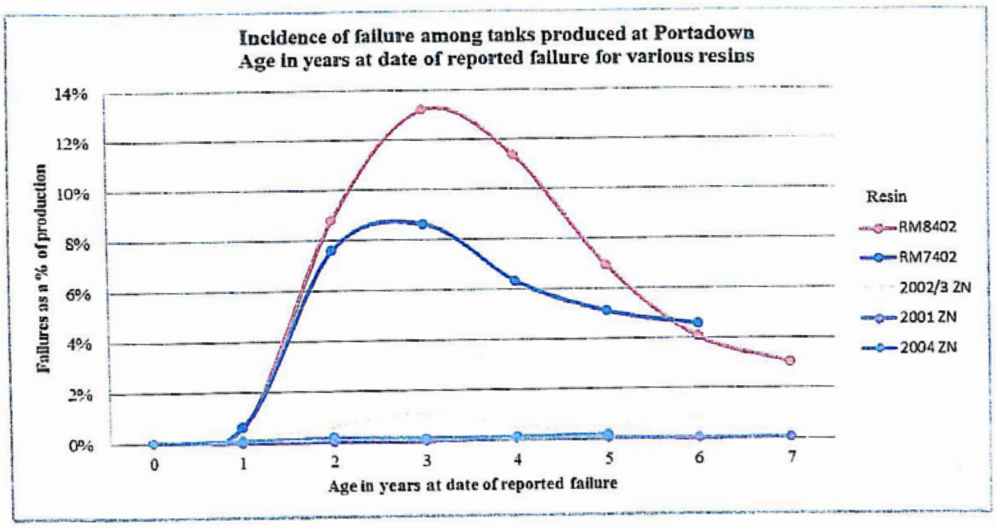
d) where they also differ by shape of tank.

686. As to a) even with a generous allocation for tanks that have failed but have not been the subject of complaint, or which have been withdrawn from service for some reason other than failure, there are many tens of thousands of tanks that have not failed - a fact which, even allowing for differences in shading and exposure is inconsistent with a generic defect. If the material is inherently defective, every tank must be imbued with the defect and a very large proportion should fail.

687. It is logically possible for every tank to be defective (in the sense that the material has an inherent tendency to crack under the effect of UV light) but for that defect only to manifest itself in a limited number of cases according to the extent of exposure to UV light and other factors. But that explanation for the statistics is, it is submitted, implausible in the light of the sheer size of the numbers involved. It would be odd for a general UV resistance deficiency to manifest itself in only 30% of cases. Dr Nugent regarded the fact that so many tanks had not failed as a very strong indicator that Kingspan could make viable tanks from Borecene. Further the tailing off of failure was, in his view and that of Professor Marshall, not what one would expect if failure was attributable to a generalised defect consisting of inadequate UV/weathering resistance, whose effect would increase with increased exposure.

688. As to b) the defect relied on is inadequate resistance to UV light. The effect of UV light is cumulative over time – and yet the rate of reported failures of Borecene made tanks, whilst it rose initially (during the early years when, on every test, Borecene was sufficiently stabilised) drops over time, particularly in relation to tanks made at Banbridge and Portadown: see figures 1-4 and 9-12 of Hasselll 13.4.11. Figure 10, for example, is set out below:

Figure 10



See, also, figures 49 – 52 of Nugent 1; figures 5 – 8 of Marshall 1 and figures 1- 2 of Marshall 2. If weathering was the cause failure rates could be expected to continue to increase over time.

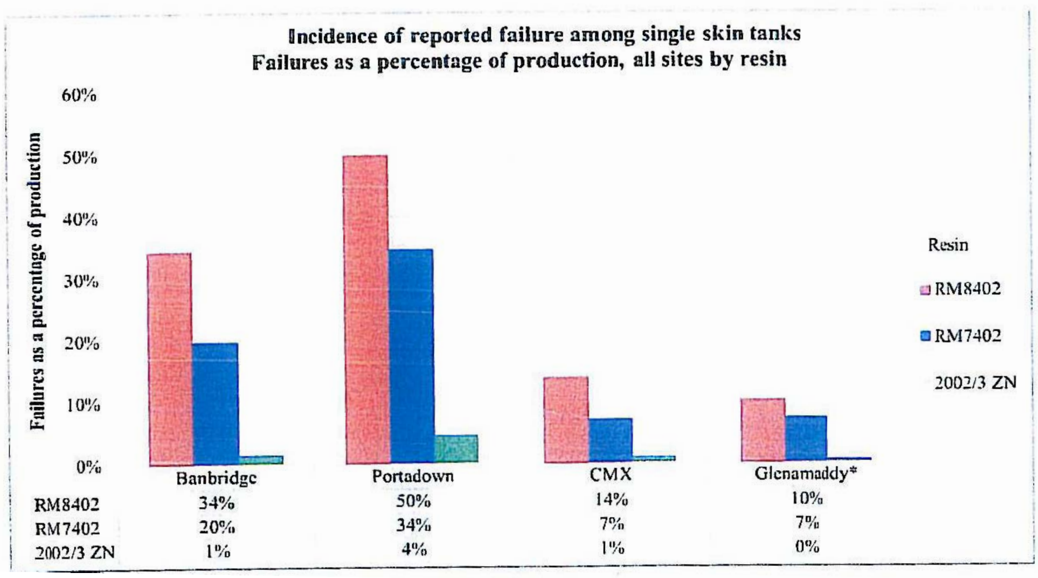
689. This "infant mortality", particularly in relation to tanks supplied for use in the UK and Eire (with a relatively low level of UV exposure), is consistent with design or manufacturing defects and represents the separation of the weakest tanks from the

general population; but does not fit well with a general UV inadequacy which could be expected to demonstrate a rising curve of failure. UV degradation of PE takes place slowly – Professor Marshall could not understand how it could be said that surface embrittlement occurring within 18 months[72] could be attributed to a difference in the stabilisation package.[73] The most recent data at the time of the hearing also showed a decline in reported failures for both RM 8402 and RM 7402 at all factories.

690. As to c) and d) these differences are inconsistent with Borecene having an inherent deficiency, i.e. inadequate UV resistance (whether as a result of the molecular structure of Borecene or the quality/quantity of the stabiliser), which would be applicable across the board. Failure rates at Glenamaddy and Carrickmacross were between c 7 % and 14% which, although too high, reveal that the vast majority of tanks have survived. Those rates were markedly less than the other two sites. Dr Nugent's examination of tanks revealed that the thickness measurements of, and shot weights for, tanks made at Glenamaddy and Carrickmacross tended to be greater than for similar tanks made at the other facilities: Nugent 1: 4.4.6.3. In some cases there were also more favourable design features e.g. smoother angles or a reinforcing feature.

691. The variation in failure rates at different factories is illustrated by the following table from Hassell 1[74]:

Figure 15



The large difference in the *rate* of failures reported at Portadown and Banbridge as compared with Carrickmacross and Glenamaddy cannot be explained by any inadequacy of the raw material or additive. It implies a difference in the quality of the tank production at these two factories with the latter having more controlled and optimised processing practices. Dr Botkin accepted that the difference between the

[72] As recorded in the photos in the Returned Merchandize Authorisation forms (RMA) e.g. Figure 26 of Marshall 1.
[73] None of the tanks which failed within 2-3 years appear to have been retained by Kingspan; so that it has not been possible to inspect them to confirm whether their failure was likely to be related to such defects.
[74] See also figures 12 and 13 of Marshall 1.

factories would have to be explained by something other than the inherent quality of the Borecene.

Under reporting in Eire

692. In response, Kingspan submits that there is likely to have been a significant degree of under reporting in the Republic of Ireland. In this respect they rely on certain failure statistics from inspections in the Republic of Ireland in December 2010 and January and February 2011.

693. These revealed that of the 36 Borecene tanks checked 35 were cracked; compared with 3 out of 25 in ZN. None of the Borecene tanks had been reported as failed. A similar pattern was apparent from further joint inspections.

694. Borealis relies on the following points. The inspections which their representatives attended, were not "blind". Kingspan's representatives had visited the sites in advance to find where the cracked tanks were. Those who attended some of the inspections on the part of Borealis were only able to look at a minority of the tanks listed for inspection: e.g. on 24-5 January 33 out of 89 houses. On one occasion one of the representatives – Dr Rutherford - spotted a tank in a house not on the list where, as it turned out, the tank – made from Borecene - was not cracked.

695. I do not regard this as a very persuasive point. If it were the case that Kingspan had been to a number of locations; identified the cracked and uncracked tanks at each location and selected the worst location, the evidence would be deeply flawed. There is no evidence of that or something like it.

696. More significant is the fact that by the time of the inspection only the Carrickmacross tanks were within warranty. Glenamaddy tanks were not. So no warranty claims were available to be reported in the case of the latter. Only 22 Carrickmacross tanks were inspected and only 4 of them were Borecene. This is a statistically inadequate sample for extrapolation purposes, as Ms Hassell agreed.[75]

697. The reasons put forward for the supposed under reporting as advanced by Mr Roberts, a Kingspan Environmental claims manager, were these: (a) the larger number of housing estates whose (often temporary) tenants had little interest in the fabric of the building; (b) the propensity of such tenants in multiple occupation to spend less time in the garden than single occupants and therefore to have less occasion to notice a cracked tank; (c) the greater use in the ROI of solid fuel (coal, peat, logs) because it is cheaper, and the consequently less frequent filling of tanks (and with lesser amounts than a full tank load), filling being the occasion when cracks are usually discovered; (d) the fact that oil delivery drivers in Great Britain were supposedly trained to check for cracks when filling (in order to avoid insurance claims); and (e) a rumour learnt from an insurance company of oil companies offering incentives to drivers to check for spot cracks, whereupon the companies would commission a new installation on the basis that a sticker advertising them would be attached to the new tank.

[75] Other single inspections give a different picture. Professor Marshall was taken by an oil company to a housing estate in Oakham where some 40-50 tanks had been installed and 3-4 were cracked.

698. I agree that these reasons are speculative and not particularly convincing. They are no more than Mr Roberts' non expert opinion, unsupported by any cogent data or detailed analysis, of the comparison between ROI and the United Kingdom, including, in particular, Northern Ireland. There are differences between the market in the ROI and in the UK, such as the greater quantity of small independent distributors in ROI. It is possible that there was a greater awareness in the UK of developing problems with Borealis' tanks because of the problems suffered by Balmoral, the concentration of sales to a smaller number of customers, the network of oil tank installers and the fact that the Northern Ireland Housing Executive was alerted to problems with Borecene made tanks as early as 2004. There may well have been some underreporting in the Republic. But I do not believe that the very marked difference in failure rates as between the Republic and the United Kingdom is likely to have been in large measure attributable to a difference in the quantum of reporting.

699. The evidence of inspections in the ROI is relied on as indicating that the total figure of c 85,000 tanks which have not been reported as failed contains a very significant proportion which have in fact failed. I am sure that it contains some and that the number cannot be known. But, again, it seems to me unlikely that it contains a significant, much less a very significant, proportion.

700. The variation in failure rates by design is illustrated by the following tables in relation to Banbridge and Portadown.

Figure 18

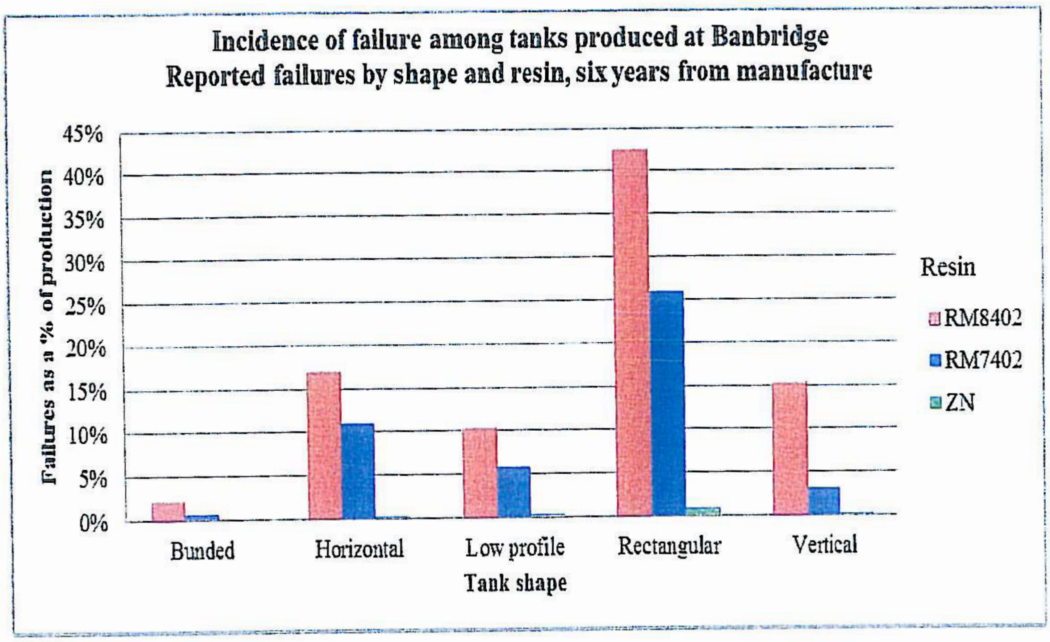
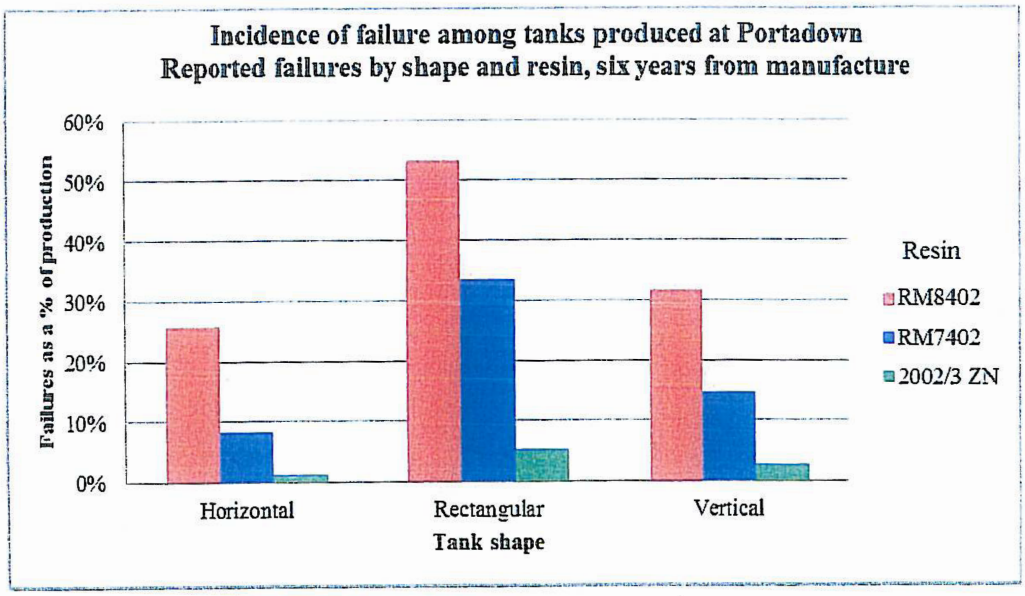


Figure 19



701. These differences (apparent also in Marshall 1 figure 14) cannot, Borealis submits, be explained by the alleged uniform deficiency in the raw material. The more credible explanation is that the designs where there was a higher failure rate incorporated higher stresses and that the design and/or processing of the tanks was the factor determining failure. Dr Botkin accepted that design must have played a part in the failures.

Discussion

702. In my judgement the points advanced by Borealis in paragraphs 683 – 691 have very considerable force. I do not find it easy to reconcile the number of unfailed tanks, the decline in failures after 3 or 4 years from production, and the difference in failure rates between factory and design with an intrinsic defect in all Borecene supplied. Mr Fenwick submitted that the only variable that explains why only some tank fails is exposure to UV; but the data to which I refer indicates variables of factory and design which are independent of weathering and a pattern of failure which suggests some other cause.

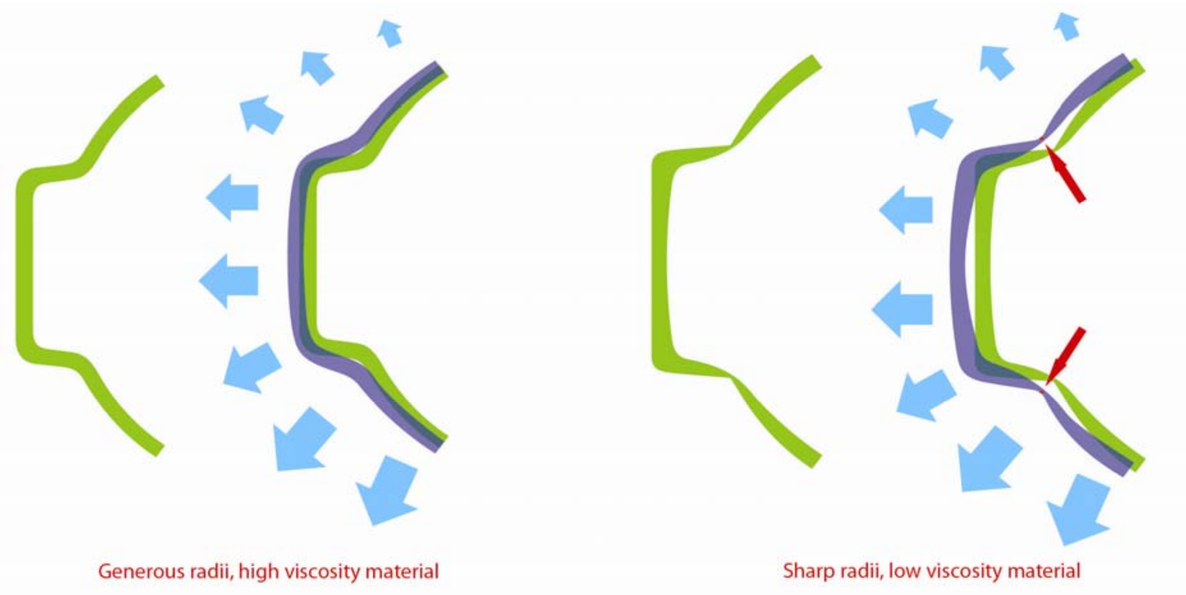
Bunded tanks

703. Kingspan relies upon the marked difference in reported failures between the inner layer of a bunded tank and single skin tanks, the latter failing to a greater extent than the former. They submit that this phenomenon arises because the inner tank is not exposed to UV light and indicates that it is Borecene's susceptibility to degradation following UV exposure which is the likely cause of failure. They submit that, if this was not so, you would expect to see many more bunded tank failures e.g. at the parting line (where there is said to have been a manufacturing defect).

704. As to that, firstly, there is – see the evidence of Dr Nugent and Professor Marshall - likely to have been significant under reporting of inner tank failures for more plausible reasons than those said to lead to under reporting in Eire. Such failures will

not be apparent where cracks have occurred at the top of the tank, above the level of the oil, which has not perceptibly leaked.[76] Only the fill port area will be visible to home owners and delivery personnel. It may be (no available data gives any answer) that under reporting is not the sole reason for the difference; but it is likely to account for a substantial proportion of it. Secondly, the inner layers of ZN bunded tanks also failed at significantly lower rates than ZN single skin. Although the difference in absolute numbers is not great, the fact that it exists indicates that, regardless of material, tanks fare worse in an environment exposed to heat and UV which degrade all polyethylenes. Third, it does not follow from a difference in the failure rate of the outer compared with the inner layer of the bunded tank that satisfactory tanks could not be made using Borecene.

705. Kingspan also rely on the fact that, generally speaking, tanks are failing on the topside of features. That is consistent with the fact that UV plays, as is common ground, a significant part in the incidence of failure since it is an initiator of degradation. Kingspan also draws attention to the fact that where there are bumpers around tanks, stresses are, *ceteribus paribus*, generally higher on the bottom side of the bumper because of the gravitational and outward force of the contents. This is illustrated in Mr McDonald (Borealis' tank design expert)'s figure 26. The fact that failures have generally been on the topsides of bumpers is, it is suggested, a reason why the cause of failure is likely to be inadequate UV resistance and not any processing failure.



706. There is some force in that point. However, as Mr McDonald observed when the point was put to him, all other things are very rarely equal. The incidence of stresses will be subject to the precise geometry of the lower half of the tank (e.g. whether there is a foot or other feature) and the relative stresses at the points marked by the arrows may be different, with the topside being higher particularly if the uppermost corner is thinner than the lower one (for an example of a very low thickness in an above bumper measurement see figure 104 of Nugent 2).

Other factors

[76] Dr Nugent reported that 80% of the population of complaints in respect of bunded tanks which he examined related to leaks at the parting line, the effect of which would have been readily detectable, and not cracks.

707. There are a number of other factors which Mr Allen listed, each of which, he submitted, was (i) an impediment to any conclusion that Borecene was defective in the manner relied on; (ii) suggested that the cause of the increased Borecene failures is some variable factor(s), and (iii) had to be explained if I was to accept what he described as Kingspan's "*monolithic*" case, which could, if well founded, be expected to result in a high degree of consistency of failure rates and times to failure.

708. The factors were these:

i) the absence of complaint by other users about inadequate UV stabilisation. Inadequate UV resistance was never suggested in the Balmoral litigation. According to Ms Fatnes' evidence, which I accept, Borecene has been used in many outdoor applications – tanks, boats (including her own), toys, tractor roofs, fish bins and the like without any complaint anywhere of a want of UV stability;

ii) the inner part of bunded tanks, which are not exposed to UV light, fail in the same way as single skin tanks and in the same way as between Borecene and ZN: see figures 27 and 28 of Marshall 1; Nugent 1, para 594. Dr Botkin had no explanation for this;

iii) tanks crack in places which have no or limited UV exposure, e.g. at the vertical boss next to the filling port on certain tanks, where the wall sections at the inspection boss corner were frequently much thinner than elsewhere on the tank surface: Marshall 1:326 and 571; and at bases;

iv) ZN tanks fail in the same locations and in the same brittle manner as Borecene tanks: see para 715 and 747 (a) below;

v) the fact that ZN tanks fail itself suggests that Kingspan is doing something wrong. ZN material is not said to be defective. In tanks which hold hazardous material capable of doing environmental damage no failure rate is acceptable (as Mr Beneke and Professor Marshall agreed and as I accept). The actual failure rate was, according to Hasselll, between 1 and 4%[77], save at Glenamaddy, which, itself, should have served as a warning that there was something wrong with the design or the process;

vi) Borecene tanks have been found to fail in a brittle manner with localised degradation immediately next to polyethylene which is not degraded and is ductile – this does not suggest a defective raw material; the same localised degradation appears in ZN material: see, further, para 753 below;

[77] The experts agree that in determining the quantum of any claim it is necessary to deduct from any figure for tanks that have failed a percentage of total production which represents the tanks that would have failed anyway i.e. if the claimants had continued to use ZN material.

vii) Professor Spoormaker's EaB experiments are inconsistent with the tank failure data: they revealed no difference between Borecene and ZN when they are irradiated: see para 822 below;

viii) Professor Spoormaker found that the inner bund of an RM 8402 tank was more degraded than the outer bund (see paras 838-9); and

ix) Kingspan must prove that UV weakness was an effective cause of the tank failure. Their experts have floated other contributory causes: e.g. a mystery ingredient (Spoormaker); poor Environmental Stress Cracking Resistance i.e. resistance in the presence of kerosene[78] (Schindler); and increased stress compared with ZN. In those circumstances Kingspan has to show that the cracking was not the result of effective causes other than a defect in Borecene e.g. a failure to reduce stress levels by improved design and processing.

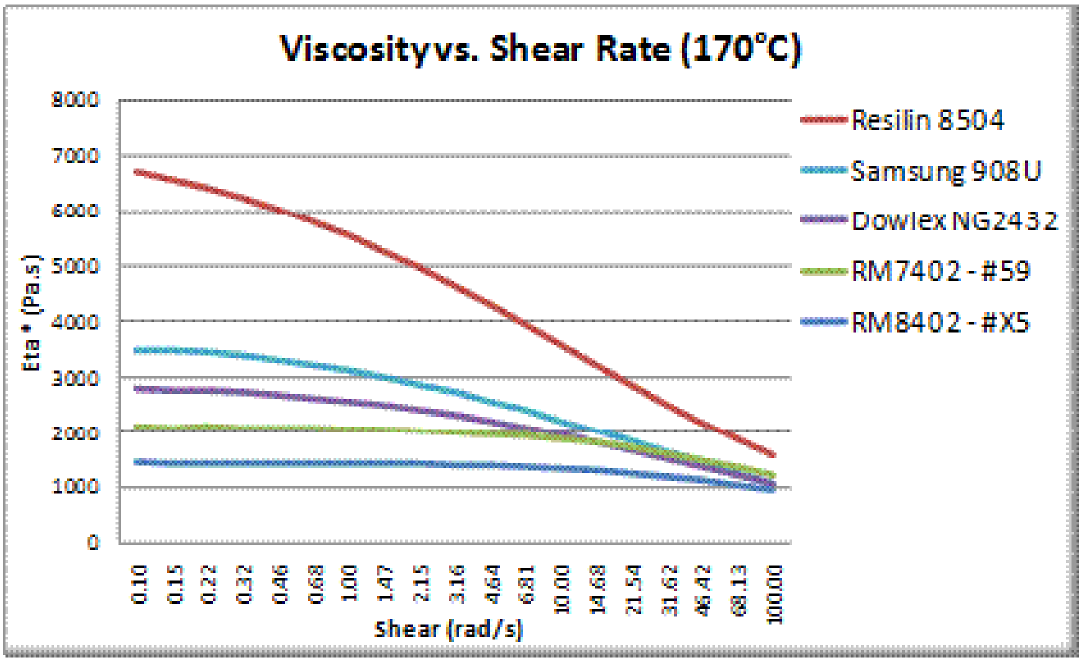
709. I regard points i) – viii) as significant indications that inadequate weathering resistance is not the probable cause of increased failures. I consider Professor Spoormaker's tests below.

The potential significance of the increased failure rate for Borecene

710. As to Kingspan's reasoning, an increased failure rate for Borecene compared with ZN does not of itself mean, as I accept, that Borecene was defective, if there is some other possible explanation. Such an explanation is available in the present case. Borecene RM 8402 and RM 7402 were different products with a lower viscosity at zero shear. The difference between the various products is illustrated in Table 85 to Nugent 1. This was not a defect but a characteristic; indeed it was a positive advantage, since such a material will process more quickly and flow more readily than conventional ZN material.

711. Table 85 is reproduced below:

[78] Inferior ESCR has not been pleaded and it is not open to the claimants to rely on it. The defendants would be unacceptably prejudiced if they were allowed to do so. I would have been particularly reluctant to allow any amendment, if it had been sought, in view of my rejection of poor ESCR as a cause in the *Balmoral* case. In any event I do not believe that exposure to fuels is a factor contributing to the increased through thickness cracking in issue in the case.



The vertical axis is a measure of viscosity. In order to carry out the relevant test a piece of material is placed between two discs, of which the topmost is fixed. The horizontal axis is a measurement of the rate at which the motor is turning the lower disc. In its technical as opposed to its colloquial sense shear thinning is the response of material to increased shear rate. Thus Resilin, whose viscosity decreases markedly as shear increases, displays significant shear thinning. RM 8402 shows very little shear thinning since its viscosity scarcely alters as shear rate increases.

712. As any competent rotomoulder should know, it cannot be assumed that a new material with different characteristics e.g. an increased MFR, will behave in the same way as a previous material. If you change material you need to see how it works and whether it is satisfactory with your design, in your moulds, and with your processes (e.g. rotation speeds and oven time) and pigments, and whether you need to make any changes to any of those. (You also need a rigorous quality control system). In particular, in the present context, it is necessary to see how the new material flows and distributes itself, especially at sharp corners. Only the rotomoulder can do this. Kingspan did trial the material in their moulds before sending tanks off for testing at Athlone – but when Mr Halvorsen asked them to cut up a tank during a trial so that he could look at the corners to see how the polymer had been distributed, he was told that that could not be done because PDC wanted to send the tank to Athlone – something which Dr Nugent described as incomprehensible and Mr Schindler as astonishing. The suggestion that tanks should be cut up to measure the thickness and the thickness variation was made by Mr Halvorsen on more than one occasion.

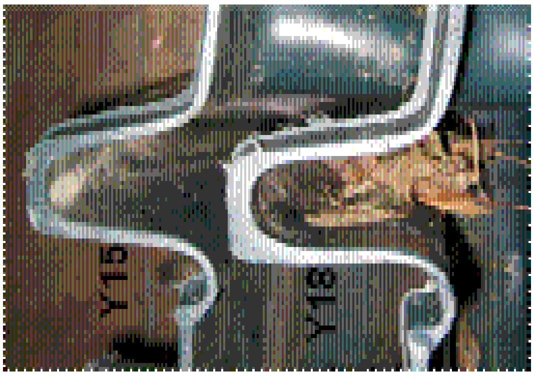
713. The design of the Kingspan tanks involved, especially in some models, sharp corners and small radii. The effect of sharp corners is that material flows more easily round corners so that it is more difficult to control the distribution of the polyethylene around them. This may give rise to thinning at internal and thickening at external corners. (This is known in the trade as "shear thinning": cp the technical meaning of the term: see paragraph 711). That in turn produces a variation in wall thickness. Thinning and thin/thick variations produce increased stress at critical points. Increased stress is an initiator of cracking. If the new material (ZN or Borecene) has a

higher MFI and, thus, a lower viscosity i.e. a lower resistance to flow, this effect may be increased, particularly where processing has not been optimised for the use of high melt flow rate material.

714. Dr Nugent's report gives a number of examples which he observed, from the limited number of tanks that he was able to inspect[79], of rotomoulding/design failure modes (i.e. locations where tanks had failed on account of problems of design and processing) including undue thinness and excessive wall thickness variation – some of which had been flagged up in contemporary emails by Kingspan or appeared in customer service notes.

715. He observed that tanks exhibited typical failure patterns for particular designs and that the failures occurred in similar locations for both Borecene and Z-N materials. The design features at which these failures occurred were all changes in section (e.g. corners or at the intersections between tank surfaces) and not on the flat surfaces away from changes in section, and the vast majority were associated with thinning of the cross-section and high stress locations. He also observed wide wall thickness variations in failed tanks with some measurements being exceptionally thin. There were also significant differences in wall thicknesses in respect of the same material made on the same machine: see Nugent 1 – figure 112 at para 510; or on the same mould used on different machines.

716. Shear thinning is illustrated in the following photograph taken from Dr Nugent's report. It is readily apparent from the cut-up tank (R 1225) but extremely difficult to predict with computer models.

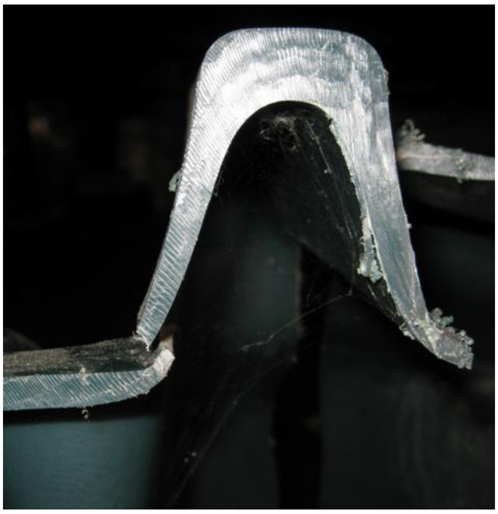


717. In this photograph the material has flowed readily off the sharp internal corners (in the photograph the corners at the top and bottom of the gap caused by the protruding feature) where there is, therefore, shear thinning, and has accumulated at the external corners. During the initial stage of the moulding process the powder is deposited and layers are built up successively, starting with the small particles where there is the highest surface area to volume ratio. The amount of material built up on the internal corners will be influenced by the heat transfer to that area (heat transfer to external corners may be greater because both sides of it are more exposed to the moving air of the oven), the rotation setting and the angularity of the design. One potential effect of thinning is to cause stress concentrations at critical locations which exceed the design stress. Thinner areas will flex more easily than thicker ones, giving rise to something

[79] In 2008 Kingspan gathered for review 299 of their tanks: 250 had been in service of which 223 were failed Borecene tanks, 15 failed ZN and 12 non failed ZN.

of a hinge effect. In relation to the R 1225 tank in the photograph failures frequently occurred at the upper internal corner. ZN tanks also failed at that location.

718. The photograph below is an example of failure at a thin section. The crack may have begun at a spot which was thinner than the point of failure which is immediately apparent.



719. Kingspan, who must or should have been aware of the matters set out in the previous paragraphs, failed to make any adequate check in relation to these matters. They did have a teledictor (an ultrasonic gauge which tells you the thickness of the material) but not, save in the case of GSP, one which would work at corners (although there are such devices). It was the evidence of Mr Scotson that Carrickmacross had a teledictor which could take measurements at corners provided that the corner was not too sharp ("*it would do a fairly broad curve*"). The effect was that they did not check the thickness at points where a check was most needed. Nor did they, when changing material or regularly in the course of production cut up sections of the tank to look and see what the thickness was, even though Mr Halvorsen had suggested it at trials which he attended.

720. More fundamentally, there was, in the present case a mismatch between the design of the tanks and the reality of their construction. Kingspan relied upon PDC to design their tanks. PDC used for that purpose the technique of Finite Element Analysis.

Finite Element Analysis and Kingspan's process of testing tanks

721. Finite Element Analysis (FEA) is a computer based programme which can be used to model plastic oil tanks. It simulates the stresses, strains and deformations that a tank will experience in operation and under applied load. It was a relatively new design tool which Mr Gregg described as not the norm in rotational moulding until 1990. Mr McDonald did not use it until 2003 or 2004. It was not a requirement of the OFTEC Standard.

722. Kingspan was one of the early adopters of the system. It was used by PDC to ensure that products of a particular design complied with the OFTEC Standard and in particular the 42 day deformation test and its high pressure test (sections 4.2.6.1/

5.2.6.1: see paras 111 and 112 above) and to predict the structural performance of the product after 25 years under normal operating pressure.

723. PDC used a value of 4.2 Mega Pascals (MPa) as the design stress for tanks, even though polyethylenes had a yield strength of 19 MPas. When there was a new design of tank the FEA programme would initially be used on the assumption that the intended shot weight was applied as a uniform wall thickness. If the mould was small enough to fit on PDC's rotational moulding machine it was trialled at PDC. Otherwise trialling would take place at one of the factory sites, usually Banbridge, often with PDC personnel in attendance. PDC did not itself have the facilities for conducting tests on the materials. The production of a sample would reveal whether the tank warped or suffered from obvious deformation and whether it was either over or undercooked.

724. In practice the wall thickness distribution of rotomoulded products will vary, particularly if they have ribs or similar features. After the initial trials of sample tanks of the new design of tank, the actual wall thickness data from the moulded part (measured by the use of a teledictor at specific points in the tank or by cutting through sections and measuring thickness with a micrometer) would be fed back into the computer model to validate the accuracy of the model using that wall thickness data. If necessary, changes would be made. Preliminary testing was done to determine compliance with the 42 day deformation test.

725. If the testing validated the FEA model and the site had satisfied itself that the sample tanks conformed to the OFTEC constructional requirements, the tank(s) in question would be submitted for testing to Athlone. Athlone would subject them to the tests set out in section 4.2 of the Standard. It would then produce a report of the test result and send it to the relevant site. If the tank passed the requirements Athlone would issue a test-house certificate to the site. The site would send the certificate to OFTEC who would issue an "OFCERT" certificate to the site with a licence number for the tank type in question, which would appear on the tanks. The site was then free to start commercial production of the tank.

726. The 4.2 MPa figure is said to have resulted from a number of PDC reports and consultations with material suppliers and academics. According to Mr Gregg, it is a value used in what Kingspan regarded as the nearest comparable standard – one (which Mr Gregg's statement does not identify) for rupture tests for underground pipes. I have not seen that standard. The figure was adopted at some stage under the Australian Tank Manufacturers' Standard.

727. Mr Beneke, Borealis' design expert, suggests that this was an inappropriate approach and that the appropriate standard to apply was BSEN 1778-1999 *"Characteristic values for welded thermoplastic tank constructions – determination of allowable stresses and moduli for design of thermoplastics equipment"*, which shows an allowable design stress of 2.47 Mpa. This figure does not take into account residual stress, which is not ordinarily modelled in FEA simulations, although, in Professor Williams' view it should be. The effect is that, if tanks were made in accordance with the design stress used – 4.2. – they would be over stressed by comparison with the 2.47 figure by about 70% and the margin of safety to be found in the use of the latter figure would be eroded.

728. Kingspan submits that the 2.47 figure has been inappropriately calculated by adopting the value of 1.6 rather than 1.06 for the value of A_{2k} used in the formula set out in para 88 of Beneke 1 derived from BSEN1778-1999 "*Characteristic values for welded thermoplastic constructions determination of allowable stresses and moduli for design of thermoplastics equipment*". (The use of 1.06, which BSEN 1778 indicates, would produce c 3.75 MPa). The 1.6 figure was derived by Professor Marshall on the basis of a comparison of stress regression data for samples loaded in air and kerosene and is said to reflect the prejudicial effect of dry blending, whereas the 1.06 figure is based on the use of compounded material. I do not think it necessary to resolve this controversy.

729. Kingspan contends that these criticisms are misplaced. First, the 4.2 figure was conservative. The FEA analysis was carried out with sharp edged radii which would exaggerate the stress. That latter point seems correct in principle, as Mr McDonald accepted, although, as he observed, the thinning at corners – revealed by the FEA carried out in 2004/5 which led to a redesign of some tanks - eroded any safety margin. Second, Kingspan used a linear FEA software package which exaggerated the peak stresses. In such an analysis the hypothetical load is applied in one step and not incrementally and no account is taken of the redistribution of stress over time as the material displaces. That is true although the extent of such redistribution is unclear. Third, the standard relied on by Mr Beneke has a safety factor of 2 so that when considering when tanks will be likely to fail in fact, rather than what precautions should be taken, the limit should be doubled. This would take the appropriate threshold, on his calculations to 5. That seems to me a fair point. Fourth, the FEA analysis carried out by Sean Gill of Kingspan in 2004/5, which revealed high stresses in the H 1300 tank and led to some redesign of tanks, post-dated the period in issue as did the FEA undertaken by Mr Beneke and the underlying data on which he worked. All that is true but that does not reduce the insight that that data gives as to the effect of Kingspan's designs.

730. I do not regard it as necessary to determine whether the appropriate design figure was 4.2, 3.75 or 2.47; nor do I regard it as possible to be dogmatic about it. Self-evidently, the higher the figure the lower the margin of safety.

731. What is significant is (a) that both Mr Campbell and Mr Beneke found in the tanks which they analysed[80] (both as designed and as moulded and particularly the latter) significant areas, e.g. on the roof (where Kingspan made the tanks thinner), where the stress was above, sometimes very greatly above, the 4.2 MPa threshold (e.g. between 9 and 14 MPa), and was excessive even when allowing for visco elastic redistribution; as is (b) the disconnect between design and practice referred to in the next paragraph. As to (a) the hotspots coincided with the crack locations on the tanks which suggests that excessive stress was responsible.

732. In designing tanks the Kingspan designers assumed a particular standard wall thickness e.g. 7 mm which applied to the R 1225 tank and 6 mm which applied to the H 1300 tank. But that was not communicated to the factories. They built tanks in accordance with the OFTEC 4.5 minimum wall thickness specified in section 4.2.4.

[80] Mr Campbell's analysis was of the R 1225, H 1300 and H 2500 tank designs (based on ZN material). Mr Beneke's analysis replicated the work of Mr Campbell in respect of the R 1225 tanks and also covered a Borecene made R 1225 tank as designed and as moulded.

That minimum has, however, nothing to do with structural integrity or lifetime. It was to ensure that the tank was sufficiently resistant to permeation by kerosene.

The spread sheets derived from Mr Schindler's report

733. A set of spread sheets produced in the course of Mr Schindler's cross examination and derived from appendices to his report shows a series of thickness measurements, made by him, in respect of R 1225, R 245 and H 1300 tanks made on various dates in 2002 and 2003 on different moulds at Banbridge (R 1225 and H 1300) and Portadown (R 245). The tanks were cut from the front to the centre along the parting line for the R1225 and 245 tanks and perpendicular to the parting line for the H1300 tanks. Wall thickness data was obtained by Mr Schindler at 56 locations for the R 1225 and R 245 and 48 for the H 1300 tanks. These locations are identified at E 3/2/2-7.

734. These examinations revealed that, in respect of the R 1225, with an FEA design thickness of 7mm, there were a substantial number of locations where the thickness was less than 7 mm but more than 4.5 mm, in many of which cracks had appeared (marked in blue on the table). In several others (marked in yellow) the thickness was less than 4.5 mm (i.e. below the OFTEC requirement and so should never have been sold to the public as an oil tank) in some of which (marked in red) cracks had occurred. In only one instance was there a crack when the thickness was more than 7 mm. The same spread sheet provides data in respect of ZN material where the same pattern of cracking at wall thicknesses below 7 or 4 mm is not apparent and where there is only one reading below 4.5.

735. In relation to the R 245, where the FEA design thickness is not known, there are a very large number of figures below the OFTEC 4.5 mm standard several of which are remarkably low e.g. 1.90 2.60, 3.14, 3.52. 3.83 mm. In several locations Borecene made tanks had cracked where the thickness was less than 4.5mm.

736. In relation to the H 1300 the FEA design assumption was a thickness of 6 mm. Most of the cracking occurred at point 47 where all but one of the measurements were below 6 mm. At point 48, however, all the measurements were comfortably above 6 mm. There was thus a marked variation in wall thickness e.g. at worst a difference between 4.29 and 10.7 mm - in respect of a tank made from RM 8402 on 24 August 2002. The result – a weak part of the tank right next to a very stiff part - causes differential deflection with the application of stress, which, as Mr Schindler accepted, can impose significant and variable dynamic loads on the polyethylene. He confirmed that he would not have allowed tanks out with these characteristics; although observing that, if something works, rotomoulders often allow a tank out even if the thickness difference is not ideal. The average thicknesses for point 47 by material were ZN = 6 mm; RM 7402 = 5.2mm; and RM 8402 = 4.8 mm – a pattern which is consistent with the increasing rate of failure of tanks made from the different materials.

737. The data also showed that for R 245 the average wall thickness at internal corners in Zone B (on the top where the main cracking occurred) was greater in the ZN material than the RM 7402; and the same applied in respect of H 1300 in respect of both RM 8402 and RM 7402 and in respect of those Borecenes as compared with Samsung in respect of R 1225.

738. The picture presented by this data, which relates to both types of Borecene, different tanks, and different dates, is that, in practically every case the tanks had in several places a wall thickness that was less than as designed and/or less than the OFTEC 4.5 standard.

739. This is only one, Borealis submits, of the respects in which Kingspan has been at fault in a manner that is likely to have been caused or contributed to the problems that Kingspan has encountered. I consider this topic further in paras 883 - 972 below.

The expert evidence

740. I have received evidence from the following technical experts:

For the Claimants

a) *Dr James Botkin*

He is an expert on polymer degradation and stabilisation with extensive practical experience in industry, particularly at CIBA, and as a consultant. The import of his evidence was that the stabilisation systems used in RM 8402 and 7402 were less robust that those used in the ZN grades and inadequate for a material meant to meet the weathering requirements of the OFTEC Standard. This view was largely based on an analysis of some of the weathering tests that been carried out over the years and a consideration of the extent to which pigment could augment the weatherability of natural polymer. He was an honest and competent witness and prepared to accept a number of points that were put to him on behalf of Borealis, including his own mischaracterisation of the Letter of Conformity as a representation that RM 8402 *would* meet the OFTEC Standard (as opposed to an expectation that when processed according to good manufacturing practice it would meet the requirements). It was, however, surprising that he had omitted to set out the Polimoon results in his first report.

b) *Ms Elizabeth Takacs*

Ms Takacs is an expert in the field of rheology. Her evidence was not entirely easy to follow (perhaps because of language difficulties) and I found some of it apparently contradictory. Some was not vouched by or was inconsistent with the sources which were said to support it: see, for instance, Day 27 35[2] – 40; and 56 - 65[81]. She had some difficulty in focussing on the question being asked and not going off at a tangent (a characteristic in which she was not alone). I was surprised at her inability to recognise what the x and y axes of an MWD graph in her report represented. Her central thesis was that the chemical properties of Borecene, and in particular its narrower MWD and smaller proportion of higher molecular weight chains, rendered it more susceptible to heat and light promoted degradation than ZN. Her evidence did not indicate

[81] The former reference relates to para 59-60 of Takacs 1 where increased crystallinity was said to increase susceptibility to ESCR and degradation when the article cited suggested that metallocenes were better able to resist ESCR because of their higher crystallinity. The latter relates to para 110 of Takacs 1 where a reduction in crystallinity upon weathering is said to increase the rate of degradation when the article cited refers to an increase in crystallinity on weathering which is said to be associated with more embrittlement.

whether there was any particular level of average molecular weight or MWD which would be unacceptable.

c) *Professor Jan Spoormaker*

Professor Spoormaker is a consultant who was previously professor of Reliability Engineering of Industrial Products at the University of Delft. He carried out conventional EaB comparator tests. When these showed no significant difference as between Borecene and ZN in terms of UV resistance, he stopped them. Thus, although the samples were exposed to 5,546 hours in the WOM he only carried out tests on samples exposed for 3,200 and 4,800 hours, those tests having failed to establish any difference between the two materials[82]. He was asked to presume that the tanks cracked because of the raw material; and carried out further tests to establish a difference between the two materials. Given the similarity between Borecene and ZN it is understandable that he should seek to discern a difference between the two with a view to explaining the increased incidence of Borecene failure. But I was left with an impression that he was more focussed on establishing evidence of a difference in order to support the presumption than on a more open inquiry as to the cause(s) of failure.

d) *Professor Gordon Williams*

Professor Williams is Emeritus Professor of Polymer Engineering at Imperial College and, inter alia, a member of the Royal Society. He is highly experienced and obviously an expert in the field of polymer engineering. What he described, on more than one occasion, as the goal of his evidence when carrying out Single Notch Creep ("SNC") tests was to find a difference between Borecene and ZN materials. Once that was achieved he did not carry out further tests e.g. on a larger range of samples.

e) *Mr Peter Schindler*

He used to work for Dow, a competitor of Borealis, all his working life where he developed a good working relationship with Kingspan and PDC, and, in particular, Dr McDaid between 1997 and August 2009[83]. He was engaged in providing technical assistance to assist sales. During his time at Dow he carried out a number of tests to which he did not refer in any of his reports, some of which (impact and tensile tests) revealed concerns that he had about the brittle failure resulting from the in-mould dry blending process used by Kingspan. I found his evidence of limited assistance. His evidence on topics other than rotomoulding and processing is not expert and Dr Nugent's experience on those topics is considerably greater.

For the Defendants

[82] His equipment was such that he was not able accurately to measure the starting point and so was not going to be able to establish the point at which 50% failure was achieved; but even so it is surprising that he ceased the measurement.

[83] Borealis only learnt about that relationship from an oblique reference in an email to McDaid of 9 December 2002.

i) *Professor George Marshall*

Professor Marshall is an expert in the properties of, and defects in, plastic materials. He was from 1990 – 2000 the Professor of Polymer Engineering at Manchester Metropolitan University. I found his reports clear, cogent and practical. He did not accept that inadequate resistance to UV was the cause of the increased failures. In the tanks he saw the appearance of the cracked sections was no different as between ZN and Borecene tanks; and ZN tanks had failed in the same way. He could not identify any specific property which could account for the step change in failures. He regarded the trends in failure data as inconsistent with a general defect.

His view was the tanks which failed in brittle mode did so because they had been degraded locally in a pattern not consistent with general UV or weathering exposure. They did so in areas (almost exclusively at corners and section changes) where because of poor design or processes the tanks were subject to stresses that were not sustainable. Where there were significant stress concentrations only modest surface embrittlement was needed to cause cracking. In other areas degradation causing severe surface embrittlement allowed failure to occur in areas where there were lower stresses.

ii) *Dr Paul Nugent*

Dr Nugent is an expert on rotomoulding processing and its effect. He is not an expert on tank design itself, as opposed to the effects of design features on the rotomoulding process. I found him an impressive witness on account of the clarity of his reports and their analysis, which appeared to me to reflect the inherent probabilities.

I was invited to treat his evidence with real caution because there had, after his development of the Rotolog[84] at Tyrell in the late 80s and early 90s, been a dispute between him and Mr Scott (who worked for Tyrell or PDC) which, as he accepted, "bounced off" other members of the company and caused some rancour. I have borne this is mind but I do not regard it as having affected the content of his evidence. Nor do I regard him as not independent, as I was invited to do, because he has been highly critical of Kingspan and, it is submitted, sought to argue Borealis' case from the witness box – a criticism equally applicable to some of Kingspan's witnesses in relation to Kingspan's case.

iii) *Professor Vincenzo Malatesta*

He is an expert in the field of UV stabilisation and the use of additives to protect against degradation with extensive experience in industry. He is not an expert in rheology. I found his reports clear and convincing, if, on occasion, repetitive. His conclusion on UV stabilisation was that Tinuvin 783 was an improvement on Tinuvin 622 and that, taken as a whole, the tests carried out supported Borealis' belief that the stabiliser packages for 8402 and 7402 were suitable for use in oil tanks and did not suggest any UV related weakness in

[84] A process control system for rotational moulding – basically a sophisticated thermometer.

Borecene. None of the results indicated that the package used was significantly worse than that used in the ZN grades such as might begin to explain the very large failure rates e.g. 50% of rectangular tanks at Portadown.

741. In addition I heard evidence from Mr Campbell for Kingspan and Mr McDonald and Mr Beneke for Borealis on tank design.

742. The number of expert witnesses is large and the content of their reports enormous. The reports have been prepared against the background of a running argument between the parties as to whether or not Kingspan was bound to state exactly what caused the tanks to fail, Borealis contending that they could not understand the case against them without this information and Kingspan contending that it was not necessary for them to establish exactly why the tanks failed, provided that a defect in Borecene was the cause. Although the latter proposition is correct[85], what exactly caused the tanks to fail and what exactly was the reason for any increased tendency to degrade, if it can be discerned, is of substantial evidential significance.

743. Paragraph 4.1.3 of the Joint Memorandum of Technical Experts reads:

> *"Kingspan experts' view is that Borecene was defective in that it had a tendency to degrade and become brittle, with the result that tanks manufactured from the material were susceptible to crack initiation and/or propagation, and then failure. Furthermore, the Kingspan experts have proceeded on the basis that they do not need to allege or establish the precise scientific reasons(s) which caused Borecene to have the tendency to degrade, become brittle and crack, nor the precise technical mechanism(s) by which such process occurred."*

744. This approach altered somewhat when Kingspan's technical experts produced supplemental reports on 25 March 2011. The reports of Dr Botkin and Mr Schindler set out, in strikingly similar terms, Kingspan's case as to the cause of increased failure of the Borecene tanks. That case has been further refined and was summarised in Kingspan's closing. In short Kingspan contends that Borecene was defective because:

i) Borecene RM 8402 (with 1,300 ppm Tinuvin 783) and RM 7402 (with 1,500 ppm Tinuvin 783) were insufficiently stabilised to give adequate protection to a static external oil tank against normal weathering and neither as good as nor better than ZN resin with 2,500 ppm Tinuvin 622. This led to early degradation and embrittlement on the exposed outer surfaces of Borecene tanks;

ii) Borecene has molecular properties (lower Mw and narrower MWD) which cause it to become embrittled when exposed to UV/weathering. When exposed to UV its viscosity and melt elasticity[86] rise dramatically and its crystallinity drops. These changes are indicative of cross linking and embrittlement or chain scission and molecular disentanglement. These changes do not take

[85] Provided that a "defect" is understood not merely as a difference between Borecene and other materials but as a characteristic which makes it incapable of being used to rotomould satisfactory tanks.
[86] A measure of how a material responds to deformation in its molten state.

place, or do not take place to the same extent, with exposed ZNs so that Borecene is much more susceptible to stress cracking; and

iii) Every Borecene tank is defective in the same way. The fact that some tanks have failed but not others is attributable to differences in exposure.

745. There is a measure of common ground between the experts. First Professor Marshall accepted that a large majority of the cracks he observed in Borecene products had been on the top or otherwise exposed parts of the tanks. This is indicative of the effect of UV exposure. All PE-type materials will become oxidised as a result of UV exposure, as well as heat and moisture, but different materials do not respond to oxidation in the same way. The oxidation which results from UV degradation, which involves fragmentation of the polymer molecules (chain scission) ultimately leads to the formation of a degraded, brittle surface layer which is generally less resistant to stress cracking. There is a reduction in impact and elongation properties. Professors Marshall and Malatesta (as well as Dr Botkin) are agreed on the significance of UV. The former described it as "*a probable partial cause*" and the latter as a common factor between all tanks that had suffered degradation on exposed surfaces and failed.

746. The oxidative stability of PE materials is affected by their composition, specifically the comonomer content. Some PE materials have a greater tendency to lose their useful properties and become brittle as a result of oxidation than other, similar materials. Compared to conventional ZN PE, Borecene appears – Dr Botkin suggests - to be both somewhat less oxidatively stable and also more susceptible to the effects of oxidation, specifically to becoming brittle due to its effects.

UV resistance

747. Borealis contends that the increased rate of failure of Borecene tanks cannot be explained on the basis that Borecene had inadequate UV resistance, for the following reasons:

a) ZN tanks have failed in exactly the same way and in the same places as Borecene tanks[87] Further, Borealis' experts have found that the nature and extent of degradation experienced by both Borecene and ZN tanks was similar[88];

b) Tank cracking has on many occasions occurred at locations not exposed to UV light, e.g. on tank bases, inner bunds, underneath end dome sections, vertical bosses next to filling ports or inspection caps (where there is an area totally shielded from the sun). For example, the majority of the 158 failed Borecene tanks examined by Professor Marshall manifested cracking at the vertical boss next to the filling port, a location which is sheltered from UV exposure[89]. The fact that cracks occur at locations not exposed to UV light (and rarely occur on *flat* panels where UV exposure is greatest) is a strong indication that

[87] Marshall 1 paras 27, 324, 350-366 and 591-5.
[88] Malatesta 1 351-376 and II 65-82.
[89] See Marshall1:28, 320-329.

the UV exposure cannot explain the reason why Borecene tanks failed in higher numbers than ZN tanks;

c) A significant number of tanks have cracked on their tops. But the tanks manufactured by Kingspan had thinner walls at their tops than at their bases particularly at internal corners. In the case of the H 1300 and R 1225 tanks the failures occurred where the FEA analysis, which assumed constant wall thickness, showed high levels of stress;

d) Cracking in areas not exposed to UV light, e.g. in bunded tanks, occurred at similar positions and by a similar slow growth process to cracks occurring on exposed tank areas[90]. This suggests that the cause of cracking of inner bunds and single skin tanks is the same, and that that cause is not exposure to UV;

e) One particular example of tanks that have cracked in spite of not having been much exposed to UV, are the tanks manufactured by Kingspan's Polish factory - Titan Eko - using Borecene RM8402 and Borecene RM7402 and new moulds - a failure on which Kingspan places some reliance. According to Gerard Kearney, the Factory Manager, 515 of the 1,000 tanks made at Kingspan's Polish factory using Borecene and supplied for use in Denmark failed. This appears to be the highest failure rate of any country. In his report of 22 October 2004 on 9 tanks located in an area close to his firm's office 4 of which had failed, he indicated that tanks in Denmark were generally placed inside wooden shelters and were thus sheltered from exposure to UV such that "*if it is a UV issue our failures could be limited*". In his witness statement he said that of the 4 tank failures out of the 9 tanks listed in his October 2004 report none were under shelter. In his oral evidence he said that he could not say which of them were under shelter. The tanks referred to in the October 2004 report which had failed had failed within a very short period of time – no more than about two years and in some cases significantly less. The very short timescale of these failures is unlikely to have been attributable to UV. Further, in view of the Danish practice to which Mr Kearney referred it seems likely that many of the 515 failures cannot have been associated with UV. It would, in any event, be startlingly odd for over 50% of tanks to fail in the first few years on account of UV exposure; and, if UV exposure was not the cause, it is likely to have been something for which Kingspan is responsible;

f) The number and trend of Borecene tank failures are inconsistent with UV being the cause of Borecene tanks failing at a higher rate than ZN tanks: see paras 685 - 691 above; and

g) A substantial number of failures occurred within 5 years of manufacture. Professor Marshall regarded that as inconsistent with UV being the cause of failure. [Dr Botkin regarded failure with 1-2 years as a result of UV degradation as "*unusual*"]. Further, the brittle failure

[90] See Marshall 1:320- 321.

observed in Borecene tanks would, Professor Marshall said, only occur at an EaB which was less than 15%. The WOM data Professor Marshall had reviewed suggested that even after the equivalent of 4 or 5 years' exposure Borecene samples still had hundreds of per cent of EaB. In those circumstances he did not believe that the failures observed in Borecene made tanks were attributable to an inability to withstand UV exposure.

748. It seems to me that all of those contentions, the factual basis of which I accept, have considerable force as indicators that inadequate UV resistance is not the cause of increased failures.

749. Borealis also relies on the localised nature of the degradation experienced by Borecene tanks. Most of the degradation has been found at corners rather than flat areas. The extent of degradation depends on the location from which the sample was taken: i.e. there is no relatively uniform level of degradation as might be expected with a generic defect. Dr Botkin contends that the localisation of degradation can be explained by the heterogeneous nature of UV degradation and is likely to be the result of stress accelerating degradation in certain areas of the tank. He refers to the particular example of a Thai Blue tank, which showed uniform degradation at the top but differential degradation at the side.

750. Professor Malatesta accepted that tanks degrade in a different manner either because they have been exposed to different degrees of irradiance; or because, although exposed to the same degree of irradiance, other factors are at work, which produce the difference. But he did not regard the localised embrittlement observed by Professor Marshall as explicable by the material properties of Borecene. Borealis contends that

variations in exposure cannot explain why corners have experienced substantial degradation but flat panel areas (more exposed to UV) have suffered far less. I agree.

751. Professor Marshall observed, in the same sample of tanks as was inspected by Dr Nugent, a concentration of degradation in small isolated spots in the same localised areas, where there was surface embrittlement and cracks had grown. These areas were at or very close to profiles (corners between flat surfaces and ribs, bosses and lugs) in the tank, although even at such changes in section there was variable behaviour. By contrast, substantial adjacent exposed flat areas were unaffected even in areas of high stress. He did not see any Borecene tanks which had suffered general degradation and susceptibility to brittle cracking across the large flat panel areas; and saw no visible signs of classic UV degradation i.e. a white chalky appearance or fine crazing, as shown in the Thai tank above. Microscopic investigation revealed a quite different picture in the case of Borecene to the one derived from tanks, whether in Thailand or Norfolk (ZN), suffering from general UV degradation.

752. His evidence, which I found convincing, was that the pattern of cracking which he witnessed was inconsistent with the proposition that the degradation was caused by the initial properties of the raw material or its susceptibility to UV weathering and must have been connected with the processing conditions when the tanks were made: see Marshall 1 274; 310 – 314 and figures 44 & 47; Marshall 2, figure 15; section 5.1. and 5.2.

753. He noticed that the Kingspan ZN failed tanks had the same cracking locations (for the pattern see Table 1 of Marshall 2) and the same cracking modes (illustrated in his Appendix S 3) and with the same degree of embrittlement (Marshall 2 paras 82 ff) as Borecene. He also noted features of (i) crack initiation, (ii) irregular pattern of embrittlement under bending, and (iii) differential types of crack formation and failure mode in areas exposed to similar UV which in his view were inconsistent with raw material defects: I: 367 – 396; 408-415; but which related to the processing conditions when the tanks were made.

754. Professor Malatesta observed the same phenomenon of cracks at corners and not in central panel areas, and in areas with minimal UV exposure in the much smaller sample of tanks which he inspected, which had been collected by Capcis in Manchester: Malatesta 1 397ff.

Stress

755. Further, Borealis submits, if stress, for which it can bear no responsibility, is postulated as the reason for localised degradation, it cannot be established that the failures were due to the inadequacy of Borecene.

756. As to stress, there seem to me to be at least two logical possibilities. The first is that Borecene was uniformly defective in the sense of having inadequate resistance to UV. There was nothing wrong with the design or the processing of the tanks. The pattern of degradation reflected the fact that tanks had greater (but not excessive) stress in some places compared with others. The second is that Borecene was not defective. The pattern of degradation reflected the fact that the tanks in question were either poorly designed or incompetently processed, giving rise to inadequate thickness and excessive thickness variation, and subject to excessive stresses on that account.

757. Accordingly, the mere fact that stress contributed to degradation is not, of itself, determinative.

758. But there seems to me force in Professor Marshall's views. I regard the pattern of degradation as difficult to square with the nature of the defect alleged and tending to contradict the theory of a general defect consisting of inadequate UV resistance.

FTIR testing

759. Borealis also submits that it is not possible to conclude that Borecene was more susceptible to degradation upon exposure to UV than ZN polyethylenes. Borealis' experts carried out Fourier Transform Infra Red ("FTIR") microscopy testing. FTIR enables the progress of polymer degradation to be followed by identifying (from their infra-red absorption spectra) oxidation products formed by oxidation of the polymer and quantifying the extent of the oxidation by reference to a parameter known as the Carbonyl Index ("CI"). By plotting the CI against the distance from the surface an oxidation depth profile can be obtained. FTIR is thus a direct measure of oxidation.

760. The FTIR spectra obtained by Borealis for samples tested on two failed tanks, an LP 1200 RM 7402 and a H 1250 ZN (the failures being after 5.5. and 8.38 years respectively), showed that both materials had experienced oxidative degradation, to a depth of approximately 0.8 mm in the case of both materials[91]. So approximately 85% of the thickness of the tank wall was without appreciable oxidation. This implies that the concentration of UV stabilisers was sufficient to protect the bulk of the tank from degradation in both cases and that Borecene had no special susceptibility to UV degradation. The highest level of oxidative degradation for both materials was at or close to areas of stress concentration at corners. There was more extensive oxidation at corner areas than tank tops (which could be expected to be the most exposed to UV). These factors suggest that stress concentration rather than UV exposure was the primary factor causing failure. The oxidation as measured by CI values was markedly greater in the case of the ZN material which was to be expected given its greater exposure: see Malatesta Table 7 (Malatesta 1, para 354).

761. The exercise found no evidence of cross linking in 3 out of 4 locations in respect of the Borecene tank and only evidence of limited cross linking in the fourth; but did find evidence of chain scission in the form of a broadening of the MWD and a shift to lower molecular weight values (demonstrated by the movement of the MWD curve to the left). The increase in crystallinity of the surface layer compared with the bulk was similar for both materials (suggesting that the level of chain scission was similar also) and a GPC study on samples from the non Borecene tank showed similar evidence of chain scission.

762. Ms Takacs took 1 mm sectioned layers from the moulded wall of one RM 8402, one RM 7402 and one Dow NG 2432 tank. She measured the extent of the viscosity increase (taking the viscosity values at 0.1 rad per sec) in 3 outer layers compared with 1 inner layer of the polymer – extending in all 4 mm from the surface. In her view, on the basis of increased viscosity measurements the depth of degradation of the Borecene tanks was 2 mm. But she accepted that the small changes in the viscosity increase in the second 1mm layer were not that significant and were likely to have

[91] Malatesta 1: 351-376.

been experienced preponderantly towards the outer layer of the sample. On the basis of these results the depth of degradation in the Borecene tanks was no more than around 1mm.

763. So far as ZN tanks are concerned Borealis found a similar depth of degradation of around 0.8mm. Ms Takacs' viscosity tests found a limited increase in viscosity in the 1 mm layer below the surface.

764. The number of tanks tested is, in the case of both the FTIR tests and the viscosity measurements of Ms Takacs, statistically inadequate. In relation to the FTIR tests the tanks had significant differences other than the materials of which they were made. They were of a different age and different design, one being low profile and one horizontal; the samples were taken from different parts of the tank; and (as in the case of practically all the samples of tanks in service in this case) their exposure history is unknown. No test was made on an RM 8402 – the highest failing - tank.

765. Each of the two types of test (FTIR and rheology) has advantages and disadvantages. FTIR testing is a direct measure of oxidation, and could on that account be treated as more reliable as a measure of degradation than viscosity increase. What FTIR does is to examine the infrared absorption spectrum and provide information on the kinds of chemical functional groups that a polymer contains. It does not provide information about the molecular architecture of the polymer including factors such as molecular weight and cross linking, which, albeit indirectly, rheology testing may provide.

766. Further PE materials will oxidise at different rates and have different tendencies to become brittle as the result of oxidation. Thus, at a given CI level it is possible for one material to become brittle and another remain ductile. A reason why the failed ZN material showed a higher level of oxidation may, therefore, be that it had less of a tendency to become brittle as a result of oxidation so that the level of oxidation that was sustained before failure was greater in the case of the ZN tank: see Dr Botkin's Supplementary Report: paras 91-5.

767. I agree that the considerations set out in the previous paragraphs mean that the CI comparison must be treated with caution. But whichever measure is taken, the data does not indicate a significant difference in the degree of degradation or that Borecene tanks in general are defective on account of increased susceptibility to degradation compared with ZN ones.

Gel Permeation Chromatography

768. The FTIR results are also consistent with a GPC analysis carried out on behalf of Borealis. Gel Permeation Chromatography ("GPC") is a method of assessment of the MWD of a polymer which was used to identify shifts in the MWD of Borecene and ZN as a result of oxidation. A similar process of degradation was apparent in the case of the Borecene tank T 97 and the ZN tank T 406[92].

Confocal Laser Spectroscopy Microscopy

[92] Malatesta 2:58-64, 75-85, 96-99.

769. Confocal Laser Spectroscopy Microscopy ("CLSM"), also known as Auto Fluorescence ("AF")[93], was carried out by Borealis' experts. The degree of oxidation reflected in tests carried out mirrored the FTIR results obtained, and suggested no difference between Borecene and ZN materials.

Ms Takacs' thesis

770. Ms Takacs' evidence may be summarised thus. The rheological data shows a much greater increase in the viscosity and melt elasticity of the outer layers of exposed Borecene as compared to ZN material. These increases are changes in the molecular structure of the polymer in response to environmental influences. They indicate that Borecene tanks have undergone a greater degree of degradation by cross linking than ZN tanks. Cross links are bonds linking one polymer chain to another. Cross linking is the opposite of chain scission which is the breaking of longer into smaller chains. Chain scission would reduce the level of entanglement and produce a reduction in the molecular weight of individual chains. Both cross linking and chain scission are forms of degradation which arise from exposure to UV. (In Professor Malatesta's view chain scission is by far the dominant mechanism as the literature indicates it is). Uncontrolled cross linking leads to embrittlement and eventual tank failure.

771. A rise in viscosity (and melt elasticity) indicates greater entanglement between the molecular chains i.e. cross linking[94]. [This is not disputed: see Marshall 2, para 119] Whereas increased entanglement may be beneficial uncontrolled cross linking, as in the present case, will or can mean that the cross-linking is happening on the weak point of the polymer. Such cross linking can be random and will not necessarily increase evenly the amount of the long chains which can help evade disentanglement. The greater entanglement effected by cross linking may be the linking together of small chains (semble with or without chain scission) rather than the creation of long ones. A very thin layer of cross-linking would be sufficient to act as a crack initiation layer.

772. However, Ms Takacs accepted that whether or not a tank would crack in the context of any given percentage of cross linking would depend on a whole variety of other factors e.g. stress, wall thickness, and the effect of pigment.

Ms Takacs' tests

773. Ms Takacs carried out tests on samples from (i) failed aged tanks; (ii) aged water conditioned tanks; and (iii) bunded fuel tanks. She also tested a variety of samples on a weathering board (a board placed on a roof to which are attached various samples).

Failed aged tanks

774. The tests on the failed aged tanks showed in the case of Borecene a very large increase in viscosity and melt elasticity on the outer surface as compared with the outer surfaces of newly moulded tanks: figure 24. The increase was much greater than that which arose with ZN material. But there was little change in viscosity and melt

[93] CLSM or AF analysis is used to identify the occurrence and extent of oxidation. When a polymer sample is excited with a short wave radiation of a laser, a visible green light is emitted by the polymer oxidation products indicating that oxidation has taken place.
[94] Testing entanglement directly is difficult. Hence the need for an indirect measure.

elasticity of the inside layers and the unexposed base: figure 25. These results were supported by GPC testing which showed that in the case of an RM 8402 tank significant changes had occurred in the molecular weight and molecular weight distribution of the samples from the exposed tops whereas no such changes had occurred in the unexposed samples[95].

775. The same tests were carried out on tanks filled with water and exposed for just over 2 years. The tests were on natural and green coloured RM 8402 tanks and on the Dow NG 2432 reference material. There were very much greater increases in melt elasticity on the outer surface of the Borecene tanks (compared with the inner) than on the Dow ones. These results are supported by GPC data: see table 4 at Takacs 1.

776. Tests on RM 8402 bunded tanks showed significant increases in viscosity and melt elasticity only on the surface layers of the bund tank (i.e. the tank whose outer face is exposed). There was little increase as between the inner and outer faces of the inner tank.

777. A further comparison showed that increases in viscosity came in the following order of samples (i) 5-6 years exposed failed single skin tank; (ii) outer tank of a bunded tank; (iv) 2 year exposed water tanks; followed by (v) newly moulded tanks and the inner tank of the bund which were practically identical.

Weathering Board tests

778. The purpose of the tests on the weathering board was to eliminate the effect of different processing conditions. The sampling fell into a number of different categories.

779. First, Borecene RM 8402 and NG2432 pellets were placed on the weathering board. 12 months exposure showed a significantly greater increase in viscosity in the Borecene pellets: figure 35.

780. Second, RM7403 tanks were moulded at 3 different PIATs (161°, 194° and 215° C) in order to observe the effects of process temperature on the weathering stability of the material. The results showed that all 3 samples placed on the weathering board for 27 months showed very significant increase in viscosity, with only slight differences between the 3 samples. The samples were not flame polished. Mrs Takacs therefore concluded that the PIAT was not having any bearing on the change in viscosity: rather, that was due to UV exposure.

781. Third, RM7403 samples were prepared with different levels of UV stabiliser (1,300 and 2,500 ppm Tinuvin 783). The samples were not flame polished. Mrs Takacs found that despite the increased amount of Tinuvin 783 both samples showed large increases in viscosity after 27 months of exposure on the weathering board, indicating severe cross linking on the surface of the tank samples: figure 37[96].

[95] There is an unexplained curiosity in the data in that one of the nine tanks samples – an aged Dow tank – showed practically no change between the bulk material and the exposed surface.

[96] Professor Malatesta suggests that this implies that any change in polymer rheology over time was not the result of a deficiency in UV stabilisation.

782. Fourth, natural and green RM 8402 and RM 7402 as well as NG2432 ZN tanks were moulded and exposed to weathering for 6 months (the ENVA tank tests). The samples were not flame polished. The tanks were either filled with kerosene, diesel or water or left empty. The results showed that the green NG2432 sample did not show any signs of significant changes in viscosity across the surface whereas the green RM 8402 exhibited significant changes in the viscosity of the surface, when filled with Kerosene or empty: figures 38 & 39.

783. In addition the viscosities of the inner and outer layers of natural RM 8402 and RM 7402 and natural NG 2432 and RG 2432 tanks were measured after 6 months: figures 40-43. The results showed very significant rises in viscosity, particularly on the inner surface of the RM 7402 filled with Kerosene (where the increase was 1,730%). Mrs Takacs explained that this was probably due to the lack of venting in the tanks and the extreme conditions (high temperature and high concentration of fuel vapour) that resulted inside: These experiments were therefore abandoned and she accepted that the results should be treated with real caution. The results in respect of the outer layer were much less dramatic (354% instead of 1,730%).

Kingspan's tests

784. Kingspan itself set up a weathering board in June 2007 for the purposes of undertaking general comparative testing. Plaques were cut from five green and six natural rotomoulded tanks produced from RM 8403 and RM 7403 as well as reference resins. The samples were not flame polished. After moulding, the rheological properties of the sectioned moulded wall samples were measured to establish baseline results. The rest of the plaques were then placed on the weathering board and measured for rheological change at intervals over 36 months: figures 42 and 43.

785. Comparison of the green samples exposed for 36 months showed that the RM 7403 and the RM 8403 exhibited increases in viscosity of 6 and 5 times that of their unexposed counterparts indicating significant material change in the surface layer. The ZN reference resins showed significantly lower increase in their viscosity at only 1.5 times higher values than their unexposed counterparts.

786. Results from the weather exposed natural Borecenes showed a severe level of viscosity increase in the surface layer at 36 months, being at least 8 times higher than their unexposed counterparts, while the ZN reference samples showed viscosity increases twice that of their unexposed counterparts. In respect of RM 7403 the total increase is not clear because the data for month 0 is missing from figure 43. It looks as if the increase is something like 15 times – more than in the case of RM 8402.

787. It is clear, therefore, that pigment was able to reduce the rate of degradation but that the rate of degradation was significantly greater in Borecene as compared with the ZN reference grade.

788. The conclusion which Ms Takacs draws from this data (no other rheological evidence has been produced and Borealis has not carried out any similar test programme) is that the increases in viscosity and melt elasticity on the outer surfaces are the result of UV/weathering. These increases are likely to be indicative of cross linking resulting from degradation (as agreed in para 3.5 of the Joint Memorandum following the experts' meeting of 27-28 January 2011) which is the cause of embrittlement which,

as Professor Marshall observed, is occurring to the UV exposed surface of Borecene samples. Such embrittlement makes the tanks more vulnerable to stress cracking.

Borealis' response

789. Borealis contends that resort to viscosity data is an inadequate substitute for a statistically significant analysis showing that Borecene tanks were more degraded than ZN tanks. In any event they contend (a) that the viscosity data is unreliable; (b) that there is no basis for regarding it as indicative of any significant amount of cross linking; and (c) that cross linking is expected to strengthen polyethylene.

The viscosity data

790. The data is said to be unreliable for a number of reasons:

a) In Figures 24 and 25 of her first report Ms Takacs compares the viscosity of the outer and inner layers of *failed* Borecene tanks with the outer and inner layers of *unfailed* ZN tanks. This is not a like-for-like comparison; and is biased towards ZN;

b) In respect of the viscosity data for *aged* fuel tanks Ms Takacs did not have the exposure history of the tanks. She accepted that in those circumstances, and with such a wide range in the data, a fair comparison could not be made between tanks from different materials. Rather the significant rise in the surface viscosities merited further investigation and it was necessary to look at the results of tests from samples on the weathering board;

c) The thickness of the samples used varied between 0.54 mm and 2.7mm. Given that the thickness of the samples can affect the viscosity measured, the comparison of different results may be flawed;

d) Ms Takacs discovered that the crystallinity of new tanks was greater than the crystallinity of aged tanks and that the reduction was greater in the case of Borecene (c 15%) than ZN (c 12%) in the samples she took: figure 28. Ms Takacs attributed the reduction to cross linking in the polymer due to degradation[97]. Since crystallinity can be effected by processing[98] a comparison between different tanks moulded at different times (as opposed to the same tank whose crystallinity is measured before and after exposure) is unreliable. In any event Ms Takacs accepted that the difference in crystallinity reduction between Borecene and ZN resins was insufficient to explain the difference in the failure rates between the tanks;

[97] As Professor Malatesta explained, crystallinity increases in an ageing sample as the result of chain scission which promotes crystallisation of the shorter oxidised chains. These can more easily crystallize because they are less entangled than the original longer chains and can get more organised in more ordered crystal structures. Per contra, cross linking which reduces the molecular mobility and freedom of the chains is expected to decrease the original crystallinity. Chain scission has been found to be the dominant mechanism for LLDPE: see Malatesta 2 68.

[98] Ms Takacs thought that the effect would not be significant. Figure 3 of Malatesta 2 would suggest otherwise.

e) Professor Malatesta caused tests to be carried out on an aged RM 7402 tank and an aged NG 2432 tank. These showed that the bulk % crystallinity values were similar for Borecene and ZN and that both ZN and Borecene experienced an *increase* in crystallinity and to a similar extent;

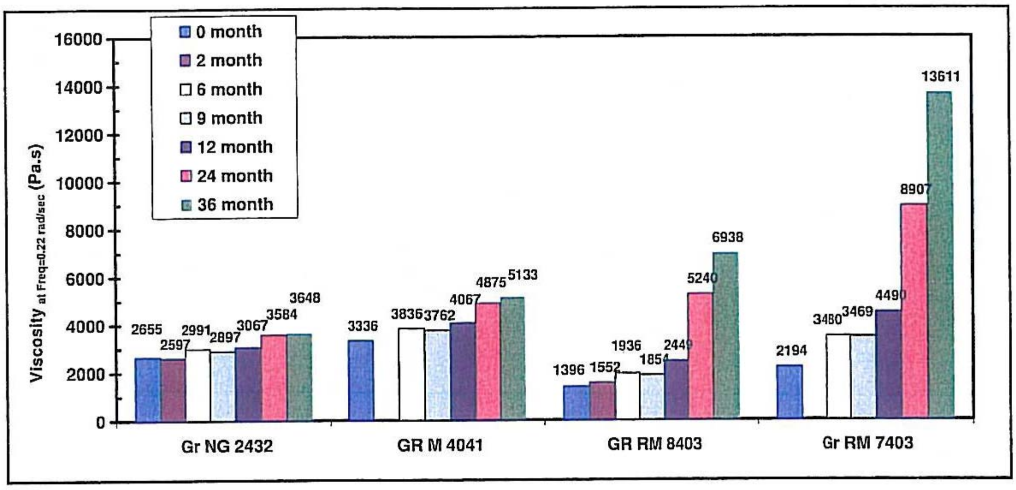
f) Ms Takacs did not comment in her report on the viscosity results obtained by Kingspan for used oil tanks manufactured by other suppliers (namely, Balmoral and DESO) which did *not* show large increases in viscosity for Borecene tanks. The results for all the test data on used tanks (made from RM 8402, RM 7402 and ZN) presented at various places in Ms Takacs report of April 2008 (the precursor to her first report) are summarised at Table 8 of Marshall 1. Ms Takacs agreed that the variation in results was so large that no clear conclusions could be drawn from the data. Professor Marshall attributed the spread of results to variations in production processes in the different factories and the varied conditions of the original surface when the tanks were first made and the location of the tank surfaces from which the samples were taken;

g) IMSG, a testing laboratory used by Borealis' experts, carried out viscosity measurements on the outer layers of 36 used, cracked Borecene and ZN tanks (a much wider range of used Kingspan tanks than the 10 tanks tested by Ms Takacs). The combined viscosity data (Minimum, Average and Maximum Outside Viscosity) obtained by Ms Takacs and IMSG for used Borecene and ZN tanks is set out at Table 7 of Marshall 1 (para 480). The Table shows no consistent value for the surface viscosity of used tanks after 5-7 years. The data shows in respect of the outer surface (i) consistently high viscosities for RM 7402, although that was not the material with the worst rate of failure; (ii) similar levels as between RM 8402 and ZN but with ZN having the highest reading; and (iii) that both Borecene and ZN materials might suffer very large changes in viscosity over time compared with that of a new tank. Professor Marshall was not surprised to see such variations having regard to the widespread variation in the cracking potential of different locations around the tank surfaces which he had observed; and

h) Viscosity measurements on 6 month exposed "ENVA" tanks (described in Takacs1:135-138) demonstrated a number of anomalies and inconsistencies. For example, natural RM 7402 tanks had a far greater percentage increase (1,730%) in viscosity than the RM 8402 or the two ZN tanks in respect of the *inner* layer; and in respect of the *outer* layer both 7402 and 8402 had a much *lesser* increase. As I have said, Ms Takacs' evidence was that the results were obtained in extreme conditions (because the tanks had no vent) and should be treated with real caution.

791. It seems to me that the points contained in the previous paragraph, particularly (e) – (g) are well founded.

792. The table relating to green pigmented samples from the weathering board shows the following (the first two sets of entries being ZN material):



793. This data is not, Borealis submits, consistent with Ms Takacs' theory that a polymer with a lower weight average molecular weight and lower melt elasticity (and, therefore, a significantly lower proportion of high molecular weight molecules) will experience greater degradation – of which increased viscosity is a symptom. On that basis RM 8403 should do worse in the viscosity data than RM 7403, since RM 8403 had significantly lower weight average molecular weight and lower melt elasticity than RM 7403. On the basis of Ms Takacs' theory and data, RM 7403 should also do worse in the real failure rates but in fact it does better.

794. Kingspan submits that it is irrelevant that changes in viscosity do not reflect failure rates. Ms Takacs was not suggesting a linear relationship between viscosity and failure and there is no evidence that such a relationship exists. Nor should such a relationship be supposed. Many factors contribute to failure. As Ms Takacs confirmed these include molecular weight, molecular weight distribution and the presence of tie molecules. RM 8402 was inherently likely to fail in greater numbers because it has lower MW, higher MFI, and a weaker stabiliser package than RM 7402.

795. It is true that Ms Takacs did not in terms suggest a linear relationship. But she agreed that, in the light of the fact that RM 8402 has lower melt elasticity and lower Mn and Mw she would expect, if her thesis was correct, to see more of a degradation effect with RM 8402 than RM 7402.

796. In order to deal with this point Ms Takacs referred in her supplemental report (para 31)[99] to the less favourable characteristics of RM 8402 referred to in the last sentence of the penultimate paragraph. Borealis contends that this is no answer. Higher MW and broader MWD indicate a greater proportion of the higher weight molecules which will have greater entanglement; and greater entanglement means slower degradation, which is shown by a lower increase in viscosity. RM 8402 with lower MW and MWD should thus be more susceptible to degradation, as indicated by an increase in

[99] Which she accepted was an attempt *"to explain away the obvious problem with the results that you've obtained?"*

viscosity. But the data shows that RM 7402 has a greater increase in viscosity than RM 8402. There seems to me force in that analysis.

797. I do not find it easy to determine the true significance of the Takacs data taken with the matters set out in paras 790 - 796 above. The tests establish the greater degree of cross linking in Borecene as compared to ZN material. What, as it seems to me, they do not establish – at any rate by themselves - is that that signifies (a) that Borecene is defective; or (b) that the defect is the likely explanation of the greatly increased failures. The imbalance between changes in viscosity and failure rates is not necessarily inconsistent with those propositions but it does not fit very easily with them.

Is increased viscosity a sign of significant cross linking?

798. There are, no test results which establish that the greater viscosity increases on the outer layers of Borecene compared with ZN tanks are the result of a significant amount of cross linking. Neither Ms Takacs nor Dr Botkin sought, or was able, to quantify the amount of cross-linking which would be likely to cause a tank to crack[100]. Nor was Ms Takacs able to specify what level of cross linking there was in the samples she considered. Professor Malatesta said that on the data available to him he was unable to relate the Takacs viscosity increases to a significant amount of cross linking.

799. K & N Labs measured one Borecene tank and one ZN tank for cross linking. This showed that there was 4.58% of cross-linked material (the figure being arrived at by measuring the gel fraction which does not dissolve in a high boiling solvent such as xylene) on the external layer of a failed Borecene tank and 0.44% cross-linked material on the external layer of a ZN tank which had not failed. In Professor Malatesta's opinion, which was not challenged, that level of cross-linking is not significant in the context of crack failure[101]. (Dr Botkin said that the figure of 4.58% was significant relative to the inner layer but could not say how much cross linking would be required to give cracking failure).

800. These two measurements cannot necessarily be taken as indicative of the amount of cross-linking in the general population of Borecene and ZN tanks and, even if they could, the small amounts of crosslinking found in Borecene and ZN do not readily correlate with the viscosity increases measured by Takacs, suggesting that there may be no necessary correlation between viscosity increase and cross linking. GPC analysis carried out by MSG at the request of Professor Malatesta on a RM 7402 tank showed that no significant cross-linking had occurred.

801. In those circumstances it does not seem to me possible to conclude that the fact that the limited amount of cross linking found in the one Borecene sample tested was greater than that in the one ZN sample tested is an explanation of the higher rate of Borecene failures.

[100] Ms Takacs claimed that a very thin cross linked layer could act as a crack initiation layer.
[101] The low percentage caused him to doubt whether the viscosity increases were in truth the result of cross linking.

802. Borealis also draws attention to the fact that certain viscosity increases observed by Ms Takacs do not relate to the UV stability of Borecene. The natural tanks rotationally moulded with RM 7403 containing 1,300 ppm and 2,500 ppm of Tinuvin 783 were exposed to weathering for 27 months. Both samples showed large increases in viscosity. But the RM 7403 with nearly twice as much Tinuvin 783 had the greater increase. I agree with Professor Malatesta that this suggests that the alleged link of increased viscosity to tank failure is not UV related and that any change in rheology over time was not related to a deficiency in UV stabiliser.

Is cross linking bad for polyethylene?

803. There is an issue as to whether cross linking strengthens or weakens polyethylene.

804. Kingspan says that there is a distinction between controlled cross linking (produced by exposure to high energy radiation or peroxide additives), which strengthens a polyethylene, and uncontrolled cross linking which may weaken it.

805. By contrast Professor Marshall's evidence was that cross linking was consistent with there having been degradation but inconsistent with there being weakening in that area and not indicative of brittleness. Cross-linking would toughen the product whether it occurred as a consequence of degradation or was artificially introduced. He believed that academics had wrongly *assumed*, without testing the assumption, that cross-linking caused embrittlement; but he had not seen any evidence of this and his experience was to the contrary.

806. Ms Takacs said that, if cross linking was *uncontrolled*, it happened on the weak points of the polymer such as double bonds which can open when they receive energy and a chain reaction involving oxidation can occur. So there would not necessarily be an increase in the long chains, whereas in *controlled* cross linking you control the site where the cross linking occurs. Mr Fenwick likened uncontrolled cross linking to the linking up of molecules in a way which was not planned as part of the design and which would or could give rise to tensions between different stresses at different parts of the materials.

807. Professor Williams said that in work on artificial hip joints (see para 809 below), which are made from cross linked PE, it had been found that if you did not get the right amount of cross linking that could produce a reduction in strength. To state categorically that cross-linking must improve toughness was not, therefore, a fair statement.

808. The distinction between controlled and uncontrolled cross-linking is not one that appears in the literature and Professor Marshall told me that he simply did not understand what uncontrolled cross linking was. He did not believe that the effect of cross linking depended on the manner (radiation or oxidation during weathering) in which the cross links were produced. Nor have any experiments been carried out to test the distinction between the two types of cross linking.

809. Professor Marshall was asked about two academic references which were said to suggest a link between cross-linking and weakening of polyethylene. The first was an article entitled "*The effects of degree of crosslinking on the fatigue crack initiation and propagation resistance of orthopaedic-grade polyethylene*", which he said was

irrelevant to the type of polyethylenes with which this case is concerned. He explained that the orthopaedic grade polyethylenes with which the article deals (and to which Professor Williams and Dr Botkin referred) were ultra high molecular weight polyethylenes with molecular weights between 2 and 6 million and were therefore "*completely different*" to Borecene and ZN materials, which had about 80,000.

810. The second was a statement in an article by Professor Crawford and Dr Nugent, entitled "*Impact strength of rotationally moulded polyethylene articles*", that "*cross-linking occurs which produces a brittle layer*". This, Professor Marshall said, was incorrect. It was written in 1992 before significant amount of work on the cross-linking of polyethylene pipes had been carried out. When he came to give evidence, Dr Nugent explained that no cross-linking measurements had been carried out in writing the article and that instead Professor Crawford and he had inferred rather than measured cross-linking.

811. I accept that cross linking may have a differential effect dependent on whether it leads to the formation of long chains or merely an increase of the length of smaller ones. But the evidence does not convince me that cross linking itself significantly weakens polymers and makes them significantly more likely to become embrittled and crack. It may be that it does; but whether, in what circumstances, and to what extent and why is unclear.

812. Further, the data before me does not indicate the extent to which any increase in cross linking may be attributed to any particular increase in viscosity or the extent to which any embrittlement of the material may be attributed to any degree of cross linking. In those circumstances the correlation – viscosity →crosslinking →embrittlement - does not seem to me established. Nor is it apparent what molecular change in the polymer is productive of the viscosity increase.

Stress

813. Stress can initiate or accelerate degradation. Energy is needed to induce degradation in a polymer, and that energy can be supplied or supplemented by stress. By supplying energy, stress accelerates the process of degradation. The significance of this lies in the fact that it is Borealis' case that as a result of poor tank design, thin tank walls, and wall thickness variation, Borecene tanks were subject to more stress, particularly at critical areas such as corners, than ZN tanks. This, Borealis suggests, is the explanation for the degradation that has occurred; or, at the lowest, the existence of this possibility means that Kingspan cannot show that any differences in the extent of degradation between Borecene and ZN tanks has been caused by a deficiency in the UV stability of Borecene.

814. As I have already indicated the significance of stress is ambivalent. In any design there are always likely to be some stress hotspots. But the fact that stress induced by poor design or processing may initiate or accelerate the process of degradation means that that is a possible explanation of what has occurred in the present case.

Professor Williams

815. For the purpose of preparing his report, Professor Williams examined failed tanks in Banbridge and in Manchester (at the CAPCIS site) over the period 2007-2010. He noted that the vast majority of the cracks were on the top parts of the tanks, and there were almost no cracks at the base of the tanks. This pattern surprised him since the top of the tank would be subjected to very small stresses. He noticed that many of the cracks had remained open after failure and that many were close to internal corners suggesting a concentration of strain there. (The inspection by Mr Humphries detailed at Marshall 2 paras 372 - 379 indicates that the number of cracks remaining open to any significant extent was proportionately not large). He postulated that the energy necessary to drive the cracks came from "frozen in strain" as a consequence of cooling during production, and that the ability of the material to withstand these strains was undermined by some environmental factor that affected the tops more severely.

816. In order to investigate his hypothesis Professor Williams examined 7 tanks, 6 of which were made from RM 8402 and 1 of which was made from RM 7402. Having taken measurements of the crack length and the crack opening, Professor Williams then sought to calculate the brittleness of the material by assuming a modulus value of 650 MPa producing, on an assumption of average strain of 1 %, a residual stress of 6.5 MPa. This was based only on residual stresses in the material; it did not include mechanical stresses. That assumption produced a figure of 31 J/m² as the energy needed to cause propagation of the crack, which he described as a very low value indicating very brittle behaviour.

817. The validity of the 6.5 MPa figure which had been used in his brittleness calculations, was understandably questioned, it being a figure 50% higher than the design stress. Professor Williams in his supplemental report accepted that the typical value for the long term relaxation of the tanks was more likely to be 300 MPa and not 650, which gave a value of 14 J/m² which he described as a very low value which demonstrated severe embrittlement. He expressed the view that mechanical stresses could well have added a further 4 MPa to the total.

818. Professor Marshall suggested that the modulus should be 150 MPa; that the value for residual stress (assuming 1% strain) would then become 0.75 MPa; that the 1% strain figure was too high and should have been 0.45% and not 1%, because the temperature changes as between temperature on release from the mould and room temperature was not as high as Professor Williams had assumed (i.e. no more than 43° C and not 85° C); and that the resultant residual stress would be estimated at 0.33 MPa. These figures seem to me more reliable.

819. Professor Marshall's calculations indicate that the cracks with which he was concerned occurred at very embrittled surfaces. I regard them as of limited assistance for the purposes of determining the cause of the greatly increased Borecene failures. They are premised on an assumption that cracks have occurred because of residual stress (which is largely influenced by factors which are in the control of the rotomoulder) without a determination as to whether they have, and, if so, how widespread was the extent of failure on that account. If, as I think likely, residual stress is not the reason for the cracks the calculations will not cast much light on what is responsible for the embrittlement.

TECHNICAL TESTING ON BORECENE AND ZN MATERIAL

Prior to proceedings

820. The testing carried out in respect of Borecene and ZN material – Series A – K above – does not appear to me to establish that the weather resistance of Borecene was significantly inferior to that of its ZN comparators. In particular it does not explain the dramatic difference in failure rates as between Borecene and ZN material. RM 8402 with 1,300 ppm Tinuvin 783 (and, a fortiori, RM 7402 with 200ppm more of Tinuvin 783) was capable of meeting the weathering requirement of the OFS T 100 1999 Standard (22 GJ/m^2) and could be expected to perform at least as well as PE with 2,500 ppm Tinuvin 622 which had proved satisfactory for many years.

821. Dr Botkin's evidence included an acceptance that there was no inherent problem with the molecular architecture of Borecene giving it inherently inferior UV stability that would make it incapable of being stabilised to UV8. In Professor Malatesta's view there was nothing about the molecular architecture of Borecene (including its lower Mw, narrower MWD and smaller proportion of higher weight chains and lower melt elasticity) that made it more susceptible to UV degradation than ZN grades or prone to quicker change once degradation had started. Further, as Ms Takacs accepted the higher crystallinity of Borecene (and lesser amorphous phase) would be expected to improve UV resistance. Professor Malatesta was of the same view – because it is well documented that oxidative degradation starts and progresses in the amorphous phase. The crystalline domains are not permeable to oxygen.

Tests carried out for the purpose of these proceedings

Professor Spoormaker's EaB tests

822. For the purpose of these proceedings Professor Spoormaker carried out some EaB tests on compression moulded and rotomoulded samples, aged in the WOM. He used a ZN Dow NG 2432 comparator. These did **not** reveal any significant deficiency of Borecene as compared with ZN in terms of UV resistance. On the contrary the rotomoulded samples failed in the order (a) ZN; (b) RM 7402; (c) RM 8402. Although samples were exposed for 5,500 hours he did not test the samples at 5,500 hours because the earlier results had shown no material difference.

Tests other than EaB tests

Additive analysis by K & N Labs

823. Kingspan arranged for additive analysis to be carried out by K&N Labs, Inc., a testing laboratory in Minnesota, using a process known as deformulation. This process was intended to analyse the level of additives, both UV stabilisers and antioxidants, in aged fuel tanks and tank samples that had been exposed to UV. Dr Botkin refers in his first report to the fact that the analysis for the H 285 RM 8402 and the R245 RM 7402 tanks, which had failed after 6 years 4 months and 6 years of service, detected no stabiliser additive in the tank top outer layer, whereas for the H 2500 Dow NG2432 tank there was still intact light stabiliser present at the surface layer.

824. I do not regard this exercise as providing a reliable indication that Borecene's stabilisation package was inadequate for a number of reasons.

825. First, the testing had a low sample size: 3 failed RM 8402 tanks; 1 failed RM 7402 tank and 1 Dow NG2342 tank which had not failed: see Table 6 of Malatesta 1. Second, a comparison between failed and unfailed tanks is not a comparison of like with like. Third, the UV exposure history of the aged tanks and the location of the samples were unknown (so that it is unclear whether like is being compared with like)[102]. Fourth, RM 8402 and RM 7402 rotomoulded tank parts were exposed on a weatherboard. So were ZN tank parts. But no samples from the latter were tested. So no comparison was possible. Fifth, the analysis may well underestimate the amount of stabiliser remaining in a tested sample because it identifies only the concentration of unchanged stabilisers; it does not detect active stabilisers attached to polymer molecules[103]. Different sizes of sample resulted in different detection limits (although this may be of limited significance) and the detection limits used meant that significant amounts of stabiliser may not have been detected.

826. On one basis the analysis suggested that the amounts of UV stabilisers remaining in the top layers of aged Borecene tanks were not significantly different to the amounts of UV stabilisers remaining in the top layers of the aged ZN Dow NG2342 tank: see Table 6 of Malatesta 1. That table, as I understand it, assumes that where the amount of additive is said to be less than the detection limit the amount of additive present is equal to the detection limit. The assumption may well be invalid; but the detection limits of the K & N equipment were high[104]. In any event, although Borecene and Dow tanks experienced depletion of UV stabilisers and antioxidants in the outer layer of the tank top, significant amounts of stabiliser remained in the middle and inner layers of the tank top which would have protected the polymer from oxidation.

827. In Professor Malatesta's opinion, the validity of which I accept:

> *"the K&N data that can be analysed shows that Borecene behaved normally under UV and weathering exposure and that the adopted stabilisation packages in RM8402 and RM7402 were still, when the tanks failed, at concentration levels that were providing adequate stabilisation to the resin."*

Professor Malatesta reached a similar conclusion in relation to the additive analysis of failed Borecene and unfailed ZN tanks, and newly moulded tank parts on the weathering board, provided by Dr Botkin: Malatesta 2 :153-181[105].

Professor Spoormaker's bending tests

828. Professor Spoormaker turned to devising a novel test with a view to establishing a difference between the two types of material. He put test strips of material into a bending apparatus in order to place a strain on them. The tests were carried out in an oven at 80° C and the specimens were scratched with a scalpel to a depth of about 0.3 mm and put under different strains. They were not flame polished. The purpose was to

[102] Absence of data on exposure history caused Dr Botkin to regard the results as "suggestive rather than conclusive".
[103] As explained by Malatesta at Day 35/62ff.
[104] Such that even if the surface contained c 300 ppm of Tinuvin 783 (23% of the initial 1,300 ppm for RM 8402) the equipment used would not detect it.
[105] Part of that data is that the biggest increase in viscosity on tank parts on the weathering board occurred in RM 7402 which had a smaller reduction in HALS than RM 8402, thus casting doubt on any link between reduction in the content of UV stabilisers and increased viscosity.

determine the time that it took to develop a crack of 1mm and the critical strain i.e. the strain below which it was likely that no cracks would occur in a period up to 1 month. A lower critical strain is said to indicate greater brittleness.

829. The categories of specimens taken included the following:

a) Specimens from rotomoulded tanks (RM 8403, RM 7403, and NG2432) exposed to solar radiation in Northern Ireland on a weathering board;

b) Specimens from rotomoulded tanks exposed to UV light in a Hanau Suntest WOM; and

c) Specimens from a RM 7402 single skin tank in service for 5.5 years and a NG2432 in service for 9 years.

830. The results, which are not very easily referenced in the conclusions of Professor Spoormaker's first report, included the following:

a) *37 month weather boarded specimens:*

i) the specimens from the weathering board cracked in the order (i) RM 8403, (ii) RM 7403 and (iii) Dow NG2432; and

ii) the estimated critical strains for these materials were 3% for RM 8403, 3.25% for RM 7403 and 5% for NG2432 i.e. the strain was about 1.6 times greater for the non Borecene samples. This is said to indicate that after 3 years of weathering the Borecene material is more brittle and to explain the cracking of Borecene tanks.

b) *Tests on unexposed specimens placed under strain in a vice in a Hanau Suntest WOM:*

i) The specimens were of RM 8403, RM 7403, and NG2432. The WOM was 0.7 W/m² (i.e. an irradiance twice that specified in the OFTEC Standard which, according to Professor Spoormaker made this experiment "*not extremely well carried out*" and produced cracking of Borecene samples after only 1 GJ/m^2) at a strain level of 4%. The 3 RM 8403 specimens cracked within 12 days. The 3 NG2432 specimens showed little or no signs of stress whitening after 14 days and had not failed after 102 days. The 3 RM 7403 specimens cracked within 18 days. A similar result arose with a 5% strain.

c) *Comparison between specimens from the RM 7402 and NG2432 tanks:*

i) The critical strain for specimens from the tops of the RM 7402 single tanks in service for about 5.5 years was estimated at 1.9%. The critical strain for specimens of NG2432 of the top of a single skin tank which had been in service for 9 years was estimated at 3.75%. Thus the ratio was about 2.

Reference specimens

831. Professor Spoormaker also conducted tests on natural compression moulded, unexposed specimens of NG2432, RM 7403, RM 8402 and RM 8403 which were placed under strains of 7% and 8% at 80°C. The samples were not flame polished. These specimens were scratched to a greater depth (0.5mm) than in the other tests carried out, in order to accelerate the tests. The purpose of the tests was to compare the slow crack resistance of the Borecene and Ziegler Natta compression moulded specimens. Since the specimens were compression moulded from virgin natural powder, the effects of (i) pigmentation, or (ii) the rotomoulding process, could be excluded. After 24 days of testing:

i) at 7% strain, all the Borecene specimens had cracked, whereas the Ziegler Natta specimen remained uncracked; and

ii) at 8% strain, all the specimens had cracked, including the Ziegler Natta specimen, but the Ziegler Natta specimen had cracked after a considerably longer period of time than the Borecene specimens.

Scratched / Notched specimens

832. Professor Spoormaker also conducted a series of tests to ascertain the effects of creating different depths of defects (the term "notching" referring to the larger defects and the term "scratching" the smaller defects). Specimens of natural, compression moulded NG2432, RM 7402, RM 8402 and RM 8403 were placed under strains of 8% and 9%. The samples were not flame polished. These tests were conducted in response to the criticisms made in the reports of Professors Marshall and Malatesta (see, for example, section 9.1 of Professor Marshall's supplemental report) about the variable notch depths resulting from the method used by Professors Spoormaker and Williams to create a defect in the materials. Professor Spoormaker found that, when placed under strain, the Borecene resins were more susceptible to cracking than NG2432 and that the method of scratching the specimens discriminated amongst the specimens more acutely than notching the material.

833. Kingspan rely on these tests as establishing the markedly reduced crack growth resistance of Borecene. Borealis submits that these tests do not establish that Borecene was unfit for purpose on account of poor UV resistance for a number of reasons.

Borealis' criticism of the bending tests

834. First, the test is unconventional. It has no proven reliability as a correlation to real in service conditions; and does not involve a cracking right through the tank wall (the mode of failure relevant for the present case). Only one ZN comparator – NG2432 – was used. That is an inadequate basis for a generalised comparison between Borecene and ZN materials.

835. Second, the tests were carried out in severely accelerated conditions leading to "failure" as defined by the test in very short time scales. The *temperature* of 80° C used for almost all the tests was significantly higher than the temperature that the tanks would experience in service and was at the upper end of permissible

temperatures for accelerated testing. Although Borealis has used temperatures of 80° C in tests, that was in the context of pipes, where standards are far more vigorous. (The impact of this point is diminished by the fact that the results of subsequent testing at 60°C on specimens taken from the top of single skin tanks showed a similar difference Spoormaker 2:87, although there was not that difference for compression moulded specimens as between RM 8402, RM 7403 and NG2432 - see para 872 below; and 60° C is still high). The *strains* of between 4% and 9% were significantly higher than the 2% to which the tanks were likely to be exposed in real life. In order to achieve the larger strains very large deflections were needed. Tests on Borecene carried out at 2% strain or lower did not generate failure. The irradiance level (0.7 W/m²) of the tests in the Hanau Suntest machine was extremely high.

836. Further, carrying out bending tests at a constant *strain* discriminates against stiffer material. Borecene was between 10% and 19% stiffer than Dow NG2432 with the result that at any particular strain Borecene would experience 10% to 19% greater stresses so that the test has a bias against Borecene. This may well have had a significant influence on failure times: see the Nova Chemicals presentation at E27:99-136. Kingspan has not sought to determine to what extent different stiffness can explain the failure time data.

837. Third, the results do not tally with the failure rates so as to explain why RM 8402 tanks failed in much greater numbers than RM 7402. The difference in actual failure rates as between RM 8402 and 7402 is illustrated by Professor Spoormaker's figure 2, where RM 8402 is the upper line:

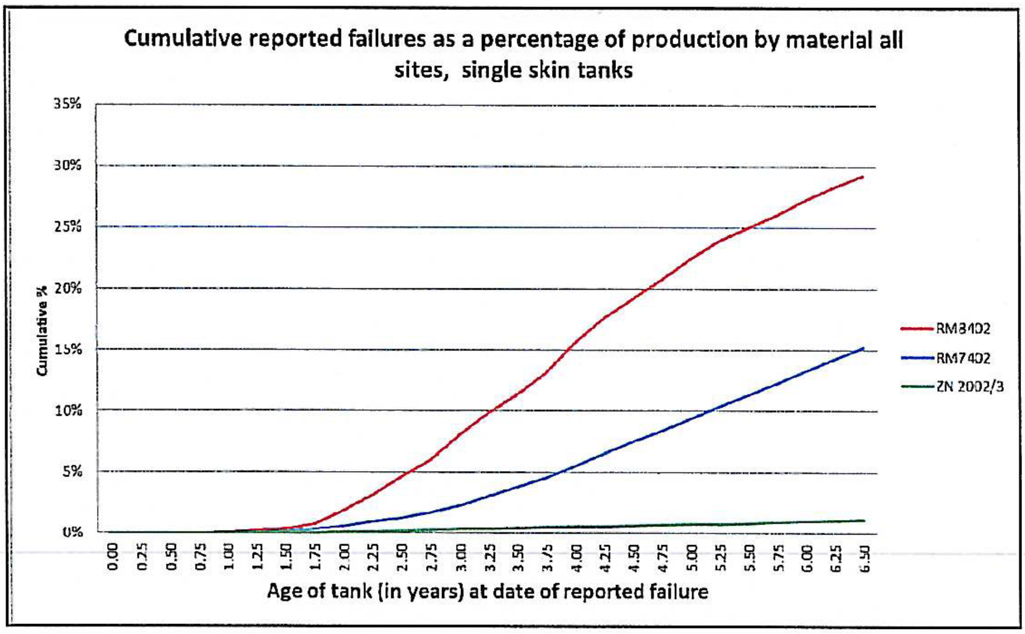


Figure 2: Cumulative reported failures as a percentage of production.

But in a number of cases the RM 7402 specimen either failed first or the difference in critical strain between RM 8402 and RM 7402 was not significant.

838. Fourth, some of Spoormaker's tests are inconsistent with the proposition that Borecene tanks failed in greater numbers than ZN because of inadequate resistance to UV exposure as compared with ZN. For instance, Professor Spoormaker tested the

critical strain of the inner and outer skin at the top and base of a bunded tank made from RM 7402 which had been in service for 7.22 years and a tank made from RM 8402 which had been in service for 7.27 years. At every strain level tested in each case the base of the *inner* tank failed before the top of the *outer* tank. If, however, a greater number of Borecene tanks failed because of their low resistance to UV you would expect exactly the reverse i.e. for the top of the outer tank to be more degraded and to fail earlier than the base of the inner.

839. Professor Spoormaker said that, on the basis of these results, it was his opinion that UV was not the only cause of failure and that, while UV may have had an influence on cracking, it was not the only cause of cracking. He believed that even in the absence of UV, tanks would fail and crack, but he had not been able to determine the alternative causes that explained the cracking of the tanks. He regarded the cracking and failure of inner bunded tank samples prior to samples from the top of the outer bund as "*the mystery of the bunded tanks*" which he could not explain.[106] A similar mystery is apparent in the stabiliser analysis conducted by Kingspan of bunded tanks where the inner bund had suffered cracking without any significant oxidation and without the top outer layer showing any appreciable consumption of stabilisers: see the summary at Malatesta 2: 282 - 290.

840. In the bending tests carried out on an aged RM 7402 tank and an aged Dow NG2432, comparison was made between a failed Borecene tank and a Dow tank which had not failed. These tests again produced inconsistent results. At strains of 3-5%, both the tank top and the (unexposed) tank base of the RM7402 tank failed within 5 days. The tank base would not have been exposed to UV in either case. So these bending tests were no indication of a reduced ability of the RM7402 tank to resist stress cracking after exposure to UV. They pointed to some other cause of failure of the bending test.

841. What some of the bending tests do unquestionably show is that there was a marked difference in the failure times of some of the UV exposed Borecene and Dow NG2432 samples, Borecene failing first: see table 4 of Spoormaker 1. Borealis contends that these differences are largely, if not completely, explained by the difference in stiffness of the two materials.

842. Fifth, the proposition which the tests are intended to support is contra-indicated by the EaB tests and also the 3 point bending tests carried out by Professor Marshall on aged tank samples with a 0.3mm notch subjected to a constant *stress* at 23° C, where the results did not indicate that Borecene had poorer stress crack resistance than Samsung ZN material.

843. I regard all these Borealis points as having force. Whilst earlier failures at higher strains might be indicative of a deficiency in stress crack resistance on exposure to UV it seems to me that they may well be a result of the higher strain itself, which does not replicate the actual conditions of the tanks, rather than a defect in the material. The test discriminates in some respects against Borecene and there are features of the results which do not tally with the thesis that the increased failures, with RM 8402 markedly worse than RM 7402, are the result of inherent deficiency in UV resistance.

Single Notch Creep Tests

[106] Day 28/98[3-25].

844. Single Notch Creep Tests ("SNCT") were carried out on UV-exposed tank samples by both Professor Williams and Professor Marshall.

Professor Williams

845. Professor Williams' tests found significant differences in the failure rates as between samples from Borecene and ZN *used* tanks. The tests in water were carried out on samples from used tanks which had stored kerosene. The samples tested included samples from (a) 1 Dow NG2432 tank in service for c. 7 years; (b) 1 Resilin tank in service for c. 8 years; (c) 2 RM 8402 tanks in service for c. 5.5 years; and (d) 1 RM 7402 in service for c 4.5 years. The tanks were selected by Dr McDaid and Dr Pick. Their exposure history is unknown. The Dow and Resilin tanks had not failed. The Borecene ones had. The specimens were machine notched and a scalpel blade was drawn along the V of the machined notch in order to sharpen it.

846. The tests identified no significant difference between the Borecene and ZN materials prior to exposure. But for samples taken from used failed tanks made from Borecene there was a drastic reduction in failure times for samples taken from the tops compared with the base: see Table 2 of Williams 1. There was some reduction in the case of the ZN tanks: thus the average time to failure for the Resilin was 37 hours for the base and 21 hours for the top.

847. Borealis submits that the data derived from Professor Williams' tests is not a reliable indicator that Borecene had a stress cracking resistance after exposure to UV which was significantly inferior in reality to that of ZN for a number of reasons.

848. First, the number of tanks tested was very limited and statistically insignificant. This is undoubtedly true.

849. Second, there was, as Professor Williams accepted, a very high degree of scatter in the results, which he attributed to the tests being highly sensitive to the preparation of the notch. There were significant variations in the notch depth (the total depth being the sum of the v—shaped machine cut and the further cut with a scalpel into the notch created by the machine). Professor Williams' experimenter did not measure his notch depths, assuming them to be 1 mm deep. In fact their average was, according to measurements by MSG carried out for Professor Marshall, 1.43mm. A difference in depths means that there may be different stresses as between one sample and another. Professor Marshall thought that small differences in notch depths might result in significant lifetime variations.

850. I accept that the high degree of scatter (with standard deviations of 40 - 60%) affects the reliability of the results. At the same time the difference in time to failure of specimens taken from (i) the top of the RM 8402 compared to (ii) the specimens taken from both the base of the RM 8402 and the top and base of the NG2432 is very striking.

851. Third, the tests were carried out at a high stress level (6 Mpa), high temperature (50°C) and in water, which accelerates the cracking process. They were short term lasting only up to 100 hours and generated very short failure times (some as short as 33 minutes). This accelerated testing was designed to discern within a short timescale what made Borecene different from ZN after it had been weathered. The entire goal of

Professor Williams' research was to discover a difference between the two materials on the footing that, if there was, the difference was the likely cause of the increased failures.

852. I am sceptical of the reliability of test conditions which depart so markedly from reality. That scepticism is increased by the knowledge that in Single Edged Notch ("SEN") tests carried out by Impact Laboratories using sets of 10 samples, which had a lower standard deviation than Professor Williams' tests, there was no significant difference in the average times to failure for the tank tops of Borecene and ZN tanks. I accept Professor Marshall's view that it is unsafe to rely on results from such short lasting tests in extreme conditions[107].

853. There are further indications which point away from that which Professor Williams sought to establish:

i) Professor Williams tested samples from an exposed area on the side of an RM 7402 tank and samples from under an adhesive label on the same tank (test numbers 24 and 25 in Phase 5). The times to failure of the samples from under the label (unexposed to UV) were lower than the samples from the exposed area of the tank[108]. He accepted that these results were contrary to a thesis that tank failures were partially or only caused by exposure to UV, and instead indicated that something other than UV was affecting the time to failure in Williams' tests.

ii) On Kingspan's instructions Impact Laboratories carried out SNC tests on four tanks (1 natural and 1 green RM 8402 tank and 1 natural and 1 green Dow NG2432 tank) filled with water and exposed to UV for two years in Galway. The lifetimes of the *exposed* tops of all four tanks were longer than the lifetimes of the shaded window areas. The lifetimes for the base, top and window of the Borecene and ZN tanks were not significantly different. The large increase in viscosity of the natural RM 8402 sample measured by Ms Tackacs was not matched by a corresponding decrease in the time to failure. These results were accepted by Professor Williams to be inconsistent with UV exposure being a cause of reduction in failure times.

Professor Marshall's tests

854. SNCT tests were carried out by Professor Marshall at a variety of stress values generating longer failure times generally up to 600 hours (and in some cases to over 3,000 hours). They were conducted in air at both 23°C and 50° C. In relation to these tests and the stress regression data resulting therefrom Professor Williams accepted, as is the case, (a) that at longer failure times there was no significant difference in the performance of Borecene and ZN resins when results were extrapolated forward to predict performance after 2 years loading; (b) that the test methodology was sensible; (c) that the conditions were more similar to actual in-service conditions; and (d) that in principle it was preferable to carry out long term tests. (Professor Williams again made plain that he carried out his tests for the purpose of discovering a difference

[107] One oddity of the results was that the lowest failure times [average 0.5] were recorded for the non-Borecene new Enva tank samples.
[108] Test numbers 22 and 23 did however show the same distinction between top and base.

between weathered Borecene and ZN materials). Professor Marshall's tests showed that brittle cracking could, in the tests, be generated at low stress levels for both materials.

Notch depths

855. There is an issue as to the significance of the notch depths used by Professor Marshall, which were, initially, 1.75 – 2mm. Kingspan submits that, since the degraded layer is said by Borealis not to extend, or not to extend much, beyond 1mm, use of a greater depth is likely to have had an effect on the results. Professor Williams says that, if 1mm was the extent of the degraded layer, you might be less likely to pick up the true crack resistance of the degraded layer.

856. Professor Marshall explained that using small notches makes it very difficult to interpret test results because if such notches are in a degraded layer it is likely that the initial notch would immediately grow upon loading (in the test) to the depth of the degraded layer, such that the actual depth of the initial notch is the depth of the degraded layer. This makes comparing the results for different samples impossible as samples are likely to have different depths of degradation so that it is unclear whether you are testing the degraded layer or not.

857. In any event (a) he carried out 3-point bending and SEN tests at different temperatures using a 0.3 mm notch, which produced no obvious difference in performance as between ZN and Borecene; and (b) the average notch depth used by Professor Williams of 1.43mm would also be notching through the degraded zone. The results of Professors Marshall's and Williams' tests could, therefore, be expected to be directly comparable.

Dart Impact tests carried out by Dr Pick

858. Kingspan also relies on impact tests carried out by Dr Pick on the tops and bases of water tanks exposed outdoors for two years and on aged fuel tanks. The water tanks were 1 natural and 1 green tank made from RM 8402 and Dow NG2432, all manufactured in December 2004. The aged fuel tanks were 3 RM 8402 tanks, 1 Resilin 8504 tank, and 1 Dow NG2432 tank. The Resilin tank was manufactured in December 1998; the RM 7402 in August 2003 and the Dow and RM 8402 in 2002. The tests were carried out at Queen's University Belfast ("QUB"). Dr Pick was employed by Titan when the tests were carried out and is now retained in a part-time self-employed capacity to assist Kingspan on technical issues related to the case.

Water tanks

859. In respect of the tests on water tanks, Dr Pick accepted that for testing carried out at 20°C and -40°C, the latter being the more important, there was no difference in the performance of Borecene and Dow NG2432. At 20°C, the samples from the tank tops and tank bases of Borecene and Dow NG2432 tanks failed in a ductile manner, whereas at -40°C, samples taken from the tank tops and tank bases of Borecene and Dow NG2432 tanks failed in a brittle manner.

860. At -10°C, there was a difference in the performance of the Borecene and Dow NG2432 water tanks. The Dow material was brittle at the tank top and the tank base.

Borecene was ductile on the tank base, but brittle on the tank top. Generally speaking ductile is preferable to brittle failure. On that footing these tests might suggest that Borecene has better impact strength than Dow NG2432.[109]

Aged fuel tanks

861. In respect of the tests on aged fuel tanks, Borealis made the following observations:

i) In Dr Pick's second witness statement, she only presented the results for the impact tests carried out on the RM 8402 R1225 tank and the Resilin R270 tank. She did not present the results for the RM 7402 tank and the Dow NG2432 tank;

ii) She accepted during cross-examination that the Dow NG2432 tank performed the worst in the impact tests at -40°C, with the Borecene materials having about 60% to 70% higher peak impact strength than the Dow NG2432 material. She also agreed that there was no difference of significance between the impact strength of samples taken from the tops and bases of the RM 7402 tank and the Dow NG2432 tank;

iii) So, by comparing the performance of the RM 8402 tank with the Resilin R270 tank but ignoring the performance of the RM 7402 tank and the Dow NG2432 tank, she was, in effect, comparing the best performing ZN tank, with the worst performing Borecene tank, which is the very same thing she criticised Impact Laboratories for in her third witness statement;

iv) The Dow NG2432 tank had not failed, whereas the Resilin R270 and the Borecene tanks had failed. There was thus an anomaly in her results, namely that the worst performing material (Dow NG2432) had not experienced failure in service while the best performing material (Resilin) had in fact cracked and failed. This suggests that her impact tests do not provide any useful data about the failure mechanisms of these tanks; and

v) In any event, it is clear from these results that it cannot be said that there is any difference of significance between the mechanical properties of Borecene materials and ZN materials after UV exposure.

862. These observations appear to me well founded.

863. It is also material to note that, although the tests were expressed as having been carried out in accordance with ISO 6603, there were departures from that standard. Under the standard the maximum permissible thickness is 4mm (para 1.3). All the samples had greater thicknesses and the thicknesses differed. The standard warns that results determined on test specimens of different thicknesses cannot be compared with one another. Further the results were expressed in J/mm. However, the increase in force that has to be applied to a sample for it to break is not proportional to the increase, but to the square of the increase, in its thickness. Expressing the force in

[109] Dr Pick said that the Dow grade "*tends to be brittle at low temperatures and it isn't a function of anything wrong with the material... there is a lot of bubbles in the Dowlex material*" and said that she relied on the result only to show that there had been changes on the surface of the Borecene tank. It is not clear to me why brittle failure is not a matter of concern for NG2432 if it is for Borecene.

terms of J/mm instead of J/mm^2 distorts the data in favour of thicker samples, which is of particular significance since Dr Pick's Borecene samples were on average significantly thinner than her non-Borecene samples.

864. In the course of his evidence Dr Botkin was referred to Professor Spoormaker's original tests which found no distinction between Borecene and ZN and which he accepted he should have mentioned in his reports. He was asked the following:

> *"Q. You make the point in your report, Dr Botkin, at paragraph 172 to 179, that Borecene has inherently an inferior UV stability than other polyethylenes; is that right?*
>
> *A. I do.*
>
> *Q. Now, we're used, in this court, to theories being advanced and verified by empirical data, but am I right to believe that what you're trying to do is, with theory, dispute empirical data?*
>
> *A. The conclusions based on an examination of not all of the data,* ***and if you examine all the data, you have to say that it's inconclusive that one is better or worse than the other.***
>
> *Q. Would you agree with me that if you look at all of the data, including, I might add, some data which it appears you have not been previously shown, it would not be possible to prove by reference to theory that Borecene inherently has an inferior UV stability?*
>
> *A. Not consistently.*
>
> *Q. But if we're talking about molecular architecture, we're talking about something which is a constant in the context of the polyethylenes we're considering. What I'm trying to understand, and forgive me, at the moment I don't understand, is why you attempt to dispute the empirical data we've looked at by reference to theory, because it seems to be counter intuitive?*
>
> *A. Meaning the architecture being related to UV stability?*
>
> *Q. Yes. The point I'm making -- perhaps I haven't put it very well, Dr Botkin -- is this, I'll try to restate it. We are used, in this court, to having experts advance theories and then verifying those theories by empirical data. What is unusual is to have empirical data which suggests that Borecene does not have an inherently[sic] UV stability, I think you've agreed with me on that, looking at data on many tests, but then subsequently to advance theory to try to negative the data which is before us. It's the reverse way around.*
>
> *A. So if I understand what you're saying, if the UV stability of Borecene is not consistently better or worse than a Ziegler Natta material, then* ***you can make no arguments concerning what effect the molecular architecture might have?***

Q. Yes.

A. Agreed.” [Bold added]

865. Kingspan submitted that Dr Botkin was not taken to all the relevant UV tests, and in particular the Spoormaker bending tests and that the evidence which showed Borecene’s inherent UV instability was to be found in Mrs Takacs’ rheology results, which establishes the relevant molecular change. I find it difficult to believe that Dr Botkin was unaware or unmindful of Professor Spoormaker’s bending tests. In addition I am not persuaded that those tests or those of Ms Takacs establish any intrinsic defect of Borecene on account of its molecular architecture. I share Dr Botkin’s view that the data is inconclusive.

Stabilisation evidence

866. Kingspan contends that the two Borecenes were inadequately stabilised at 1,300 and 1,500 ppm Tinuvin 783, especially when CIBA’s general recommendation was for 0.3% in LLDPE: see their fax of 15.5.96. Dr Botkin did not think that 2,000 ppm Tinuvin 783 was sufficient to deliver protection from 34 GJ/m². His recommendation would be for 3,000 ppm; and not less than 2,000 ppm to achieve UV8.

867. It does not seem to me that the series of tests carried out establishes that the stabiliser used in RM 8402 and, a fortiori RM 7402, was deficient. Tinuvin 783 was on any view more efficacious that Tinuvin 622 and although the quantity was reduced from 2,500 ppm to 1,300 ppm in the case of RM 8402 the data indicates that such a proportion of Tinuvin 783 in RM 8402 would be more (or at the least as) effective as 2,500 ppm Tinuvin 622.

Stress crack resistance (other than by reason of UV exposure)

868. There is, in my judgement, no basis for finding that *unexposed* Borecene has inferior stress crack resistance compared with ZN materials. The complete success enjoyed by Motoral Oy in Finland in manufacturing Borecene oil tanks (for use indoors and with different designs) confounds any such proposition as does the testing to which I refer below.

869. Professor Williams was of the view that there was no difference in the stress crack resistance of unexposed Borecene and ZN material. In his first report his “*overall conclusion [was] that these tests show that all the materials give approximately the same failure time before they exposed* [sic] *to UV*”. The technical experts agreed at a meeting that took place on 25 May 2010 that “*Single Notch Creep Tests (SNCT), conducted in water at 50°C by Kingspan expert (GW), showed no statistically significant difference between unexposed Borecene and Ziegler Natta materials*”.

870. The Single Notch Creep tests carried out by Professors Williams, Marshall and Impact Laboratories on *unexposed* samples found no difference between Borecene and ZN.

871. Professor Spoormaker’s tests on compression moulded *unexposed* samples (II 24-29) at strain levels of 7 and 8 % showed that NG2432 had a significantly greater time to failure [development of a 1 mm crack] than Borecene RM 7402 and RM 8402 but at

7% strain the RM 7402 failed before the RM 8402 – i.e. the reverse of the trend of actual failures. All the Borecene failure times are relatively close together. Further tests, not included or referred to in Spoormaker 2, showed that, in tests carried out at 7.9% strain none of the samples had failed after 10.9 days when the tests were suspended. In tests carried out at 7% strain neither the RM 7402 nor the Dow NG2432 had failed after 16.8 days. These are better results than those in Spoormaker 2 and indicate no significant difference in the stress crack resistance of Borecene and Dow.

872. Further, tests, which are referred to in Spoormaker 2 (para 88), carried out at 60°C and 8% strain on compression moulded samples, showed that after 20 days no distinction could be made between the performance of the samples of RM 8402, RM 7403, and NG2432 after 20 days (the RM 8403 had failed after 10), although RM 8402 and RM 7403 are said to have failed at some later stage. This seems to me an indication that the differences seen in the results of Professor Spoormaker's tests on compression moulded samples at 80°C is likely to be attributable to the high temperature.

873. Lastly, Ms Takacs said in evidence that she did not contend that, as a matter of theory, *unexposed* Borecene had weaker stress crack resistance than ZN because of its lower molecular weight and lower melt elasticity. On one view this seems the opposite of what appears in paras 20 and 84 of her first report, but what she appears to have been saying there, and in her oral evidence, was that Borecene has susceptibility to stress cracking *when exposed to UV*. A distinction between weak stress crack resistance and susceptibility to stress cracking on exposure to UV does not appear in the literature.

The significance of high molecular weight

874. In her first report Ms Takacs had relied, inter alia, on a passage in a book by Professor Deanin – Polymer Structures Properties and Applications - in support of the statement that "*high molecular weight provides higher stress cracking resistance"*. The passage refers to stress cracking being in inverse proportion to the number average molecular weight – *Mn* – i.e. the higher the *Mn* the lesser the stress cracking, as illustrated in Figure 3.30 in terms of impact resistance. Paragraph 67 of Professor Malatesta's first report shows Borecene to have a higher *Mn* than ME 8152, a ZN material supplied by Borealis.

875. Kingspan contends that this does not establish that Borecene had better stress crack resistance for three reasons:

a) another figure (3-31) in the same book shows that the higher the MFI the lower the stress crack resistance, which is consistent with the pattern of failure – in the order RM 8402, RM 7402, and ZN – with MFIs of 6, 4 and <4;

b) a third figure (3-32) which plots ESCR in terms of hours to failure shows that the higher the Mn the better the stress crack resistance. But it deals with material of densities between 917 and 929, which were much lower than the densities of Borecene (940) and such material would be likely to have lower stress crack resistance; and

c) in any event stress crack resistance is affected by a whole range of variables such as MFI, density and Mw. Ms Takacs explained that the more relevant molecular weight was the weight average molecular weight – *Mw*. She also explained that she had measured the G' Prime (the storage modulus – a measure of melt elasticity) of Dow and Borecene which provides an indirect measure of molecular weight and the results indicated that RM 7402 had a lower number of the higher weight molecules which enable a material to resist stress cracking.

876. Professor Malatesta referred to two sets of figures derived from the Balmoral litigation (para 240). The first set of figures derived from Mr Clements of RAPRA, Balmoral's expert; the second from Dr Clemens of CAPCIS, Borealis' expert. The first table shows the MFR 4 Borecene to have a higher Mn figure than the two ZN grades and a higher *Mw* figure than Dow 2432.

Sample	Mn	Mw	Mz
BP Rigidex	21,600	91,100	**255,800**
Dow 2432	25,400	81,600	**209,000**
MFR 3	38,300	91,000	155,200[110]
MFR 4	37,400	83,900	176,000
MFR 6	35,100	76,300	140,000

The second set of figures shows a similar position in relation to Mn but the Mw figure is below that of both ZNs.

Manufacturers Code	Nominal MFR	Mn	Mw
ME 8166/7	3	37,650	79,250
RM 7402/3	4	34,450	71,850
RM 8402/3	6	31,800	68,500
Dow NG 2432	3.8	27,100	73.750
Rigidex 4330	3	22,350	75,900

877. Kingspan draws attention to the table at para 30 above (Table 1 of Professor Malatesta's report) which shows that RM 7402 had a lower Mw than Borealis' ME 8154 tank grade ZN; and to the fact that the Mw of both RM 8402 and RM 7402 is consistently lower than the Mw of other non Borecene grades.

878. The true position appears to me to be that summarised by Professor Malatesta (para 71) namely that Borecene has, compared with ZN:

i) fewer low molecular weight chain species i.e. it has higher *Mn* values;

ii) a narrower molecular weight distribution (*MWD* – being *Mw* divided by *Mn*); and in general, although not invariably;

iii) a lower *Mw* (which gives it lower viscosity); and

[110] This figure is suspect. It should be higher than for MFR 4 and MFR 6.

iv) a smaller proportion of high molecular weight chains than comparable ZN grades.

879. Professor Malatesta did not agree with the proposition that properties (ii) – (iv) are indicators of a higher susceptibility to cracking due to thermal and UV/weathering degradation. He had not come across any theory that clearly explained why this should be so or testing that established that it was. (The same applied to lower melt elasticity which he had never seen correlated to higher susceptibility to thermal and/or UV weathering degradation).

880. I regard this scepticism as well founded. There are a number of references in the literature to the importance of Mw and molecular entanglement for stress cracking resistance and to the function of tie molecules of tieing the different intercrystalline domains together to prevent or resist disentanglement. In that respect, as it seems to me the properties specified in para 878 above may reduce stress crack resistance, particularly environmental stress crack resistance. That does not, however, indicate that Borecene is inherently more likely to begin to degrade under the effect of UV on account of those properties. Professor Malatesta pointed out that it is well documented that oxidative degradation of a polymer starts and progresses in the amorphous phase and not the crystalline domains, there being a limited permeability to oxygen in the crystalline phase. Borecene has in general a higher crystallinity (although the extent of crystallinity is to some extent dependent on the manufacturing process and, in particular, the cooling process) and thus a *lower* amorphous phase than ZN material.

881. Ms Takacs said in her oral evidence that in her view the higher crystallinity of Borecene resins improved their stress crack resistance, including UV resistance, and did not have a direct link to degradation. But in her written report she had suggested that higher crystallinity meant fewer tie molecules and thus poorer stress crack resistance. She did not proffer any measurements of the extent of tie molecules in either Borecene or ZN material. Nor has any academic article been drawn to my attention which shows that higher crystallinity or narrower MWD necessarily means that Borecene will contain fewer such molecules.

882. Professor Malatesta referred to a 2005 paper of Wang and others[111] which measured the percentage of tie molecules in a metallocene and a ZN (the metallocene having a density and MWD comparable to RM 8402 with an MWD lower than that of the ZN) and found it to be higher in the former. The material referred to was not ordinary metallocene but one produced by bimodal technology intended to improve earlier forms of single site technology. Nevertheless the exercise appears to indicate that higher MWD is *not necessarily* an indicator of more tie molecules.

KINGSPAN'S CONDUCT AND ALLEGED FAILINGS

883. In the paragraphs that follow I consider matters within Kingspan's sphere of responsibility which may have had an impact on the increased failures of Borecene made tanks.

[111] *"Single site catalysts and dual reactor technology create more freedom in PE rotomoulding resin and product design"* ANTEC 2005, Boston.

884. In order to rotomould an oil tank that is to last for 10 or more years a manufacturer has to address a number of different factors, including: (a) design; (b) specification of materials including pigment and pigment incorporation; (c) processing conditions; and (d) quality control. To some extent these interrelate. An adequate design may well be insufficient if the manner in which processing takes place means that the tank is not produced in accordance with the design. A particular design may have characteristics which with one material present no problem, but with another may do so. Weaknesses in a tank may be remedied by a change in design, material or process or by a combination of two or all of them.

885. A change in any one of these matters may make it necessary to revisit the appropriateness of the others. It cannot be assumed that the effect of a design with one material will be the same when use is made of a new material with different mechanical properties, such as a higher flow rate, or that engineering calculations or assumptions made in respect of one material are equally applicable to another. Thus a material with a lower viscosity may exacerbate the degree of thinning at internal, and thickening at external, corners, and the degree of undesirable wall thickness variation, characteristics which are themselves the product of an angular design, the effect of which may have been comparatively less when material of a higher viscosity was used[112].

886. When changing material it is, thus, necessary to see what is the effect of using the new material (particularly a very different material like Borecene) with the existing design and processes and to consider whether any change is necessary. To do that properly it is necessary to understand what thickness of material is being produced and with what degree of variation either by the use of a teledictor at many points (including, in particular, corners) or, preferably, by cutting the tank up and taking the requisite measurements. I accept the evidence of Dr Nugent and Mr McDonald to this effect. Without doing that Kingspan did not know what they were making.

887. A reasonably competent rotomoulder in the position of Kingspan – a market leader with its own research and design arm (PDC) - ought to have been aware of all of the above.

888. I do not regard the position as altered because, in their brochures, Borealis represented that Borecene with its increased flow had the *"possibility"* or the "*potential*" to reduce wall thickness and decrease the shot weight and achieve better wall thickness distribution. Whether that potential could be realised would depend on factors such as angularity of design and the processing parameters adopted. Increased flow has advantages (e.g. an ability to adapt to complex shapes) but the extent to which it does, and whether it requires variation of the moulding parameters, such as PIAT, rotation settings, orientation and insulation of the moulds and shot weight, and the relationship

---

[112] That the different flow behaviour of Borecene could affect wall thickness distribution and needed to be catered for was indicated in Borealis material. Thus the Borecene Processing Guide records: *"Optimisation for Borecene: In order to achieve the desired even wall thickness in the finished article the rapid melting of Borecene compared to that of standard material should be taken into account"*. Similarly Mr Halvorsen consistently made plain that Borecene had a tendency to a more uneven wall thickness distribution than Ziegler Natta unless you increased the rotation speed and adjusted the rotation ratio.

between temperature and cycle time[113], depends on all the circumstances including the design of the tanks in question.

889. Nor do I regard it as altered because Borecene was not a new material in the sense that it had been on sale for some time. It *was* a new material to Kingspan and it was in relation to their designs, moulds and processes that it had to be tested. That was something for which PDC was responsible.

890. Kingspan contends that this analysis is flawed. Dr Nugent's evidence was that, if you get material draining away from internal and accumulating at external corners, you could adjust the peak temperature and length of time for which the material was exposed to high temperatures i.e. reduce the PIAT and that the best way to run RM 8402 would be to reduce the PIAT to c 165 - 175° C. But, although that was what Borealis had originally advised, it was not the advice that had been given in early 2002 by Mr Ervik and Mr Halvorsen to the effect that PIAT could be increased to give a much broader processing window. Kingspan could not fairly be criticised for processing at too high a PIAT when Borealis' literature said that Borecene had a broader processing window, improved flow properties and Borealis employees had represented that it could increase the optimal PIAT.

891. I do not regard this submission as persuasive. Recommendations as to optimal PIATs made by PE suppliers are no good reason for failing to take the steps referred to in the previous paragraphs. Data from McMaster University cited by Dr Nugent suggests that Borecene would retain good impact properties even when processed at PIATs up to 240 °C. But higher PIATs would reduce viscosity and that result might be unfavourable in the case of angular designs. Hence the need on the part of the rotomoulder to examine the effect of any given choice of parameters.

892. Borealis contends that there were defects in Kingspan's design, processes, and quality control; and that they failed to take the steps set out in the previous paragraphs to see whether Borecene was suitable for their designs.

Design

893. The evidence of Dr Nugent (see, in particular paras 284-322 of Nugent 1) and of Mr McDonald and Mr Beneke is to the effect that Kingspan's tanks were poorly designed for rotomoulding purposes in that they used excessive ribbing and sharp corners. This produced (or contributed) to Kingspan's difficulty in avoiding thinning of the less viscous material around sharp features of the designs at or close to corners (e.g. at ribs, vertical up stands and filling ports), the build up of material elsewhere and significant wall thickness variations. Such variations as well as creating areas of weakness, where the tank is at its thinnest, generate excessive stress concentration[114].

894. This itself would lead to stresses in excess of the 4.2 MPa design threshold, which, according to the evidence of Mr Gregg, should have led to rejection of the design. Mr Beneke and Mr Campbell found in the tanks that they analysed that the 4.2 MPa

[113] i.e. whether to achieve a given PIAT you take a higher temperature and a lower time or vice versa. This changes the way in which the material flows.

[114] Stress is defined as s = P/A where s = Stress, P = Load, and A = area. The reduction in wall area in a member subject to bending will result in a non- linear increase in stress.

threshold stress adopted by Kingspan in their FEA calculations was exceeded in practice.

895. Kingspan did not call any of the designers at PDC, which was responsible for tank design and had a design team. Mr Gregg's evidence was that the function of FEA analysis was to predict the structural performance of the product after 25 years under normal operating pressure based on long term properties as they were predicted to be at the end of that period. To simulate long term structural performance it was essential that the material properties used by the software tool reflected the long term material performance of the product after 10 and/or 15 years of use.

896. But, he said, PDC did not design the wall thickness of the tank with UV in mind and focussed solely on loading stress and the constructional requirements of OFTEC (even though UV degradation is a possible mode of failure and even though PDC knew – because it appears in a document sent by Mr Schindler to Dr McDaid in January 1999 - that the wall thickness of a part affected the part's resistance to UV). PDC regarded it as necessary for the material they used to have an appropriate degree of UV protection but never appears to have considered how effective the various elements of the design – wall thickness, pigment (type, concentration and admixture), and processing – would be in relation to UV degradation.

897. In my view the criticism advanced of the design of the tanks by Borealis' experts is justified. The sharp angular features of the tanks (particularly prominent in the case of R 1225 and R 245) and the extensive ribbing were intended to provide stiffness - important in order to pass the OFTEC deformation test but upon which there may well have been excessive focus to the detriment of the tank's long term performance. These features were likely to produce shear thinning and undesirable thickness variations. This effect was inherently likely to increase with the use of a material with a higher MFI and a lower viscosity. Another effect of the use of sharp features is to make it very difficult to use FEA to predict the displacement and stresses during the service life of a tank (which will be emptied and refilled) compared with, say a pipe, where the stresses will be uniform.

898. Kingspan submits that this criticism of design is nothing to the point. Tanks made from ZN to the same design failed rarely and at an acceptable rate. That shows, they submit, that the designs were not defective. It was the introduction of Borecene that caused failures at a far greater rate which is essentially to blame. No one told them that they would or might have to change their designs or their processes. The general picture given was that they could switch material without difficulty.

899. I do not agree. Figure 15 in para 691 above shows that the failure rate for ZN in 2002 and 2003 was between 1% and 4%. As I have already said (see para 708 (v) above) I do not regard that rate as acceptable in a product such as an oil tank where leaking may have drastic consequences and it should have signalled a possible need to change designs or processes. With appropriate design and wall thickness a 100% success rate is achievable. Motoral in Finland achieved it for some 43,000 tanks made from RM 8402 with a much smoother and more rounded design. These were for internal use to store heating oil and in that respect resemble the inner bunds of Kingspan's bunded tanks. I accept the submission that the ZN failure rate should itself have prompted reconsideration of the designs.

900. In any event it is the responsibility of the designer to satisfy himself that any particular material can be used effectively in any given design. It was Dr Nugent's evidence, which I accept, that a rotomoulder should not switch from one material to another without evaluating and testing it and that must be on his own designs and with his own processes.

Design changes after the event

901. Kingspan did in fact make design changes in respect of some of their tanks in 2005 in the light of what had occurred. One was in the design of the R 1225 used by Titan. In August 2004 Sean Gill, a design engineer produced an FEA Report on the stress concentrations in the R 1225, which identified stress hotspots which coincided with 2 common failure locations. (The model assumed constant wall thickness which was unlikely in practice). Later reports on the R 245, H 2500 and H 1300 produced a similar picture. In respect of the latter it was discovered that in the critical area the radii had been designed to be 10 mm but were in fact between 5 mm and 7 mm.

902. A further report was made in August 2005 in respect of weak areas in the R 1225 tanks. These were redesigned by smoothing out contours and eliminating sharp radii, because it was recognised that the existing designs had features which created stress concentration. The report highlighted as weak factors (a) the vertical ribs at the end; (b) the vertical side ribs, which were tending to move out like the vanes of a concertina; and (c) the sharp intersection of the top of the tank with the rear of the upstand; and (d) sharp edges of the bosses along the top of the tank. Kingspan introduced a rib across the top of the tank to rigidise it; and they eliminated all the various radii that were causing stress concentrations on the roof of the tank. There was also a change in the rotation ratio. It is noticeable that the majority of the designs at Carrickmacross and Glenamaddy, where failures were markedly less than at the other two sites, were more rounded with less angularity and ribbing. Nugent 1: 4.3.10.

903. Further, after it stopped using Borecene, Kingspan took steps to increase wall thickness and improve thickness distribution in some of its tanks by changes to the shot weights and rotational ratio: see the evidence of Mr Carey of Titan. Titan increased the shot weight of the R 1225 and H 1300 tanks and Tyrell increased the shot weight of the R 245 tank.

Tests

904. Borealis contends that PDC should, at the outset, have carried out low temperature impact testing (widely used in industry since at least the early 90s) on Borecene to determine its mechanical properties: see McDonald 2:9.5. PDC should not have relied only upon manufacturers' data sheets because these always quote average or mean values. Even if use was to be made of *natural* material to mould parts, it would be important to determine the lowest mechanical properties on the standard deviation curve, because it is these with which an engineer needs to work. As it was, Kingspan intended to incorporate a pigment into natural Borecene by dry-blending, which was known to be the most prejudicial method of pigment incorporation. It was, therefore, important to carry out impact testing on the moulded/pigmented part.

905. Once the mechanical properties had been derived, the results should have been fed into the computer and a new FEA carried out with a nominal wall thickness. If the

FEA run using the derived mechanical properties revealed stress hotspots below the design stress, PDC should have instructed the factories to make tanks and test them (by sectioning) to ensure that there was a good correlation between the manufactured product and the FEA design. This should have been done at the trialling stage, and again during production runs at all four factories to test production tanks.

906. PDC should have considered whether its assumptions about lifetimes of ZN tanks held good for Borecene tanks given Borecene's better flow properties or whether changes would have to be made to the designs used or the nominal wall thickness to ensure that desired service lifetimes could be achieved. A competent designer would have advised Kingspan either to adjust some of the designs or to adjust processing parameters to ensure that, by using a material with better flow properties, the extreme angularity of those designs did not exacerbate a problem of thinning that was already evident from the ZN failures.

907. In fact (a) no impact testing was carried out; (b) no new FEA runs were carried out on the basis of the results of such testing or on the data from as moulded Borecene tanks; and (c) no correlation was carried out between what was designed and what was manufactured.

908. In my judgement, these criticisms of Kingspan are well founded. Kingspan's failure to carry out any of these tests was, in my view, a significant fault. Impact testing, although desirable, may not have been absolutely essential although, as Mr McDonald indicated, its omission was very surprising. Failure to carry out any further FEA testing in respect of Borecene does not seem to me justifiable in circumstances where FEA analysis was available, had been used for the original design, and was something which Kingspan were relying on to satisfy themselves that their tanks would last for the requisite time. Given that the material characteristics of PE may differ from grade to grade, it could not safely be assumed that the results of FEA analysis on ZN material were equally applicable to Borecene. It was necessary to feed into the analysis reliable data in respect of the moulded Borecene.

909. But, even if I am wrong on that, I accept Mr McDonald's evidence:

i) that destructive testing by cutting up tanks is necessary in order to verify that what has been made accords with the design of the tank;

ii) that it is and was at the time common practice in the industry (and departure from it highly unusual) especially in critical load bearing structures where layup is crucial to meeting performance criteria;

iii) that there is no point in an FEA simulation if tanks are not sectioned in order to know what is being produced, particularly if teledictor tests are carried out only on flat panels, which are those least likely to be problematic;

iv) that this should take place regularly throughout manufacture;

v) that it is not incumbent on the material supplier to suggest this; and

vi) that, if it had been done, it would probably have revealed significant wall thickness variations and sharp features which were likely to be problematic, particularly when using a high melt flow material such as Borecene, and tanks which on that account should not have been sold to the public.

The tests in fact carried out

910. Kingspan did carry out wall thickness checks, but:

a) the checks were only carried out with reference to the OFS T100 minimum thickness requirement of 4.5mm, (although there was a thicker standard for the 2600 cylindrical tank); and

b) Kingspan failed to check the thickness of tanks at corners. They did use wall thickness maps to determine the measurements at the flat sections, using a teledictor for that purpose. This was insufficient; it was the corners and changes of section that mattered most[115]. I do not accept that a full enough picture of thickness distribution could have been detected from flat section data alone. If it could the deficiencies revealed in the Schindler spread sheets could have been expected to be detected.

911. These were, in my judgement, serious errors, particularly when PDC knew that Borecene was a new material which was fundamentally different from conventional grades. The checking of tanks against OFTEC'S 4.5 mm standard arose as a result of a failure to give any different instructions and a misunderstanding at the operational level as to the significance of that figure. To design a tank with one thickness and check it by reference to another, and then not at the places which mattered most, was irrational, as Mr Campbell accepted. PDC should have given, but did not give, instructions that the moulded tanks should have the minimum wall thickness assumed as a constant thickness in the FEA programme for the tank in question. These errors meant that Kingspan lacked the necessary information with which to monitor the success or otherwise of their manufacture. As a result tanks were made which were unacceptably thin and had excessive wall thickness variations.

912. FEA testing is only a tool: and it is far from perfect. Mr Campbell regarded it as having a 3-4 year margin of error; particularly since Kingspan's tanks, unlike pipes, were complicated structures. In those circumstances it was even more important to check on thickness and thickness variations and to allow for a significant margin of error.

913. The stress hotspots on the R 1225 tank made from RM 8402 were measured by Mr Beneke for the purpose of these proceedings. The hotspots were found to be in the region of 14, 12 and 9 Mpa and coincided with the crack locations on the tanks. In those circumstances the excess of the stresses above the design stress is likely to have caused the cracks in those locations and to have been something that would have been revealed if the FEA had been run using as moulded measurements.

[115] As Mr Schindler said: "*When we would mould tanks, we would normally cut a tank and look at the critical points in the mould. We wouldn't necessarily measure it but together with the customers we look at it and they would decide whether it was okay for them or not, because they were the experts. Q. And you would cut the tank up, not least of all to look at the corners of the tank? A. Yes, of course. Corners are the most critical points. Q. And so if you're at all going to be concerned about your product, you really must look at the corners of the tanks because, as you say, they're the most critical parts of the tank? A. I agree.*"

Processing parameters

914. Borealis contends that Kingspan failed to optimise their processing parameters and that this failure exacerbated the problems created by the angular design of many of the tanks. As a result there was greater thinning of material around sharp internal corners than there was with ZN tanks. Dr Nugent's view, which seems to me compelling, is that there were certain sharp features in the moulds which in conjunction with the flow properties of Borecene would create thinning if not properly controlled during the moulding process.

915. The evidence indicates that Kingspan, although in many respects having efficient factories, did not seek to optimise their processing parameters in the light of Borecene's different characteristics, i.e. to consider whether any and if so what changes were necessary in the light of the new material and to determine, by trial and test, including destructive testing, what those changes should be.

916. Dr Nugent analysed the production records from the various factories. That and the evidence from the various factory operatives who were called indicates that what Kingspan appears to have done was to put Borecene into the machines with the same settings as had previously been adopted and without any material change on account of the introduction of the new material.

917. Thus, Titan at Banbridge made some adjustments to its processing parameters by changing oven times and temperatures. But these changes did not necessarily coincide with a change of material so that an oven time for one material continued to be used for a different one. Rotation ratios did not change according to the material used.

918. The production records for Tyrell at Portadown show that they treated all material as oil tank grade material whatever the MFI. Mr James Doran's evidence was to that effect. He said that they would not adjust the tank production specifications unless a fault was found in the tank. The records reveal a significant variation between the processing parameters on different machines often on a shift to shift basis which indicates a failure to determine and apply optimal settings.

919. The product specifications in respect of ROM and GSP show that processing parameters were not altered for Borecene, and the factory witnesses confirmed it.

920. Kingspan submit that the matters set out in the preceding paragraphs do not lead anywhere. Dr Nugent has not provided any evidence that links the increased failures to the processing behaviour to which he refers e.g. by showing that tanks made from one material have failed in large numbers when processed according to the cycle time and temperature settings designated for another; or that the use of the same time and settings has produced much greater failure for one material than another; or that when cycle and temperature settings increased there was a concomitant rise in tank failures. Variations of times and oven temperature were only to be expected as a result of the size and power of different machines, the time of year and ambient conditions in the factory.

921. I accept that evidence of the character specified in the previous paragraph would have been powerful evidence of the causative effect of a failure to optimise processing parameters. Nevertheless the evidence summarised in paragraphs 915 - 920 above

indicates that, although the material to be used had changed, there was little attempt to determine the best processing parameters – cycle times; temperature; PIAT; rotation ratios – for the new material. Thus, for instance, as appears from figure 24 of Dr Nugent's report a change from Resilin 8504 to RM 8402 in respect of the R 245 at Portadown on machines 2 and 3 did not produce any decrease in cycle time as would have been expected; and there was a general increase in cycle times for all materials in 2003 both ZN, RM 8402 and RM 7402.

922. The adjustments to processing parameters that fall to be considered if optimisation of processing is to be achieved include:

a) rotation ratios and speeds;

b) oven cycle time and temperature, the combination of which determines Peak Internal Air Temperature (PIAT);

c) control of the early stages of cooling; and

d) shot weights.

923. The PIAT affects the mechanical properties of the final product (i.e. whether it is properly cooked) and the wall thickness distribution (because it affects the flow of material around the mould). Control of the early stages of cooling is needed in order to prevent the material from soaking or lagging at high temperatures for an extended period, as a result of which the material will continue to move round the mould which would lead to greater thinning at internal corners. By controlling PIAT and the early stages of cooling you are, as Dr Nugent put it, effectively managing the viscosity profile of the material. The effect of different PIATs on mechanical properties and wall thickness distribution may be gauged by (i) carrying out low temperature impact tests; and (ii) cutting up tanks to determine wall thickness.

924. I have considered:

a) whether optimisation of processing parameters in respect of a new material in the manner set out in the previous paragraphs, which Dr Nugent advised, should be regarded as (i) a counsel of perfection; (ii) something which a rotomoulder would be well advised to do; or (iii) something that he ought to do; and

b) the extent to which a rotomoulder in the position of Kingspan, who has been making tanks without substantial failures, and who is presented with a new material as suitable for his purposes, is entitled to assume, in the absence of any significant problems arising, that no such optimisation is required.

925. In my judgement optimisation of processing parameters in the case of a new material is something that ought to be done by a competent rotomoulder, at any rate if it has higher flow properties than its predecessor. It cannot be assumed that a change of material will have no effect which needs to be catered for.

926. As appears from paras 890 - 891 above, I do not regard this conclusion as affected by the fact that Borealis, like other manufacturers, gave advice (based on results from

their own simple Rotolog system) as to the processing window i.e. the PIAT at which tanks could be moulded. This was advice of a general character in a field (rotomoulding) where Kingspan were the experts and the persons who alone were in a position to carry out tests on their moulds and in the light of their processes. I accept Dr Nugent's evidence that any such advice is a starting point. In any event Kingspan did not simply rely on what Borealis had said about processing window but carried out trials and determined the applicable PIAT in respect of the trials using their own Rotolog.

927. None of the claimants carried out impact testing on Borecene to determine an optimum processing window. No destructive testing was carried out by Titan. In respect of the other three claimants it was performed on a very limited basis. Mr Kelly of Rom said that it would be done if there was a start-up problem and a scrap tank was available but not on a regular quality control basis. Mr McQuillan of Tyrell's evidence was to the effect that destructive testing was not carried out except when there was a new mould.

928. I accept Borealis' contention that the combination of Kingspan's designs, their failure to carry out appropriate tests, and their failure to alter designs or optimise processing parameters with the new material has led to the production of very thin tanks with large variations in wall thickness distribution. Specifically:

i) In virtually every Borecene tank Mr Schindler had measured (see the spread sheets referred to at paras 733ff above) the wall thicknesses were not in accordance with the nominal thickness determined by the designer using FEA and/or the minimum OFTEC requirement of 4.5mm. All but 6[116] of them had measurements below the OFTEC requirement (where there is yellow or red shading) at some points, and were, therefore, unacceptably thin in parts and should never have been sold;

ii) Mr Schindler accepted that his measurements showed a "*major difference*" between the number of Borecene R 1225 tanks which did not meet the OFTEC requirement and the number of ZN tanks that did not do so;

iii) The results for the H 1300 tanks demonstrated that tanks were manufactured with thin sections immediately next to thick sections: compare point 47 with points 46 and 48. This, as I have said, can result in differential deflection of adjacent sections on the application of load. Mr Schindler would not have allowed such tanks to go out; and

iv) Most of the wall thickness readings for point 47 on the H 1300 Borecene tanks (which is the point on the H 1300 tanks where cracking most frequently occurred) were lower than the equivalent readings in the ZN tanks.

929. Kingspan draws attention to the fact that the majority of cracks in the Borecene tanks, the subject of the Schindler spread sheets, occurred where the wall thickness was above 4.5mm, and cracking did not occur at many points where the thickness was considerably lower. The wall thickness variations were bigger in the case of RM 8402 but the differences for RM 7402 were much closer to those for ZN. The results show,

[116] The H 1300 tanks produced on 23.7.02; 19.7.02; 17.3.03; 18.8.03, 22.6.03 and 22.9.03.

it is submitted, that wall thickness variation cannot be the key driver in relation to cracking because if it was most cracking would occur where the differences were greatest which the figures did not show.

930. The fact that in this sample (and others – see Schindler 2) (a) the majority of cracks occurred when the thickness was above 4.5m; (b) cracks did not occur at many of the points where thickness was below 4.5 mm and (c) most cracking did not occur where the wall thickness variation was greatest does not, in my view, signify that wall thinness and wall thickness variation are unlikely causes of cracking. The 4.5 mm figure was well below the design figure and related to permeation. Whether and where a tank will crack will depend on a number of factors of which wall thickness is only one. Not all failures will necessarily occur at the thinnest point of the tank. They will tend to occur at the highest stress concentration which may be where there is a combination of geometric change, material thickness variation and/or axial and bending moment. The effect of displacement on loading is also relevant.

931. Further, and most importantly, the thickness data was gathered along a single plane. As Dr Nugent pointed out, the reality is that there are likely to be thinner sections away from that plane where failure may be initiated: see figure 5 of Nugent 2. Kingspan understandably points out that Dr Nugent has done no sustained three dimensional analysis (although his figure 5 explains the phenomenon he described and he refers to other examples: e.g., para 65 and 82). That does not, however, cure the limitations on data from a single plane.

932. The Schindler data affords, in my judgement, a revealing snapshot of the deficiencies in terms of thickness and thickness variation of Kingspan's Borecene tanks which is not invalidated by the considerations advanced by Mr Schindler. I share Dr Nugent's view that variation in wall thickness (with concomitant higher stresses) is likely to have been a significant factor in the failures of the tanks.

933. The problem of the thinness of the tank wall was made worse because the claimants decided to make the tops of some of their tanks – e.g. 245, R 1225, H 2500 and H 1300 - thinner by shielding the relevant part of the mould by insulation. The effect was to reduce the heat on the part with the result that less material is attracted during the rotation process. When the tank expands with heat the sides are forced outwards and the tops of the tank experience a degree of bending. When the tank contracts stress is generated by the tank contracting against the resistance of the oil. The effect of having a thinner part on top is to increase the stress there, in some cases (e.g. H 1300 and R 1225) in an area already subject to stress hotspots. No FEA analysis appears to have been done to assess the stresses once the tops of the walls were reduced by insulation. Figures 29 and 30 of Dr Beneke's report show the correspondence between an FEA hotspot (where the tanks is grossly overstressed and is close to yield stress) and a crack on the top of a R 1225 tank.

934. Kingspan relies on the fact that, generally speaking, stresses are likely to be larger at the base of the tank than the top, on account of the hydraulic load, coupled with the fact that most of the cracking took place at the top, as strongly indicative, certainly when taken with the evidence of Mrs Tackacs, that it is inadequate UV resistance that is the effective cause of the preponderance of Borecene cracking. However, the evidence of Dr Nugent is that stresses are not necessarily at their highest at the base. (In this respect account has to be taken of what are usually the more generous and

softer features at the base). Further the design and processing of the tank may produce thin areas and thin/thick variations which create local stress hotspots. The analysis by Mr Beneke shows where hotspots on top coincided with failure. Further, if the top is thinner (so that there is a differential in thickness relative to load) either because of insulation (see previous paragraph) or poor processing this may also create stress hotspots at which failure is likely to occur.

935. Kingspan contends that if and insofar as there are similar or identical sharp features at both top and base, and if sharp features and their consequence are responsible for the failures, then more failures would be expected at the base than in fact occurred. But Dr Nugent did not collect data on the sharp features towards the base of tanks to see whether there was any difference in the relative thinness, or in the pattern of failure, as between top and base. There were some corners which he saw cut up and measured but there is no record of the data. Accordingly Dr Nugent's thesis is unvouched.

936. There would seem to me some difficulty with the contemplated exercise given what Dr Nugent described as the markedly different features at top and base and the extent of the thickness variation at the top. His evidence was that, although there were some sharp features at the base[117], generally speaking the internal side ribs towards the base had a pretty generous distribution of material without stress concentrations or sharp features to create thinning. I do not regard the absence of some such exercise as destructive of Dr Nugent's thesis.

937. By the same token Kingspan had not produced any analysis or testing which establishes that, even if the walls were thicker (so as to comply with OFTEC requirements and the designer's intention) and the variations in wall thickness less, Borecene made tanks would still have failed, so that inadequate wall thickness and excessive variation of wall thickness can be regarded as without causal significance. In my judgement it is likely that both of those (and the failure to optimise processing parameters from which they arose) were contributory factors in the failures.

Quality control procedures

938. Borealis contends that the claimants failed to implement effective quality control procedures in that:

a) they failed to measure wall thickness at corners and other changes in section, where wall thickness variation (a processing issue) is most likely to occur. Instead they used a teledictor to measure wall thickness on flat panels;

b) they failed to carry out destructive testing to any significant degree and did not do so when trialling a new material such as Borecene – despite Mr Halvorsen's requests on more than one occasion for a tank to be cut up – nor did they carry out such testing as a regular quality control procedure; and

[117] His first report gives examples of sharp features at the base where cracking has occurred when the thickness was very small: V 10000 (4.3.6.1); 600V (4.3.6.2); 300 V (4.3.6.3)

c) at Tyrell and GSP they calculated the shot weight (see the evidence of Messrs McQuillan and Doran (Tyrell), Morris and Scotson (GSP)) by reference to the minimum thickness of 4.5 mm of the OFTEC standard (itself considerably lower than the design thickness) when that standard related to the permeation of kerosene and not to the structural lifetime or mechanical performance of the tank. That was done in order to keep costs down.

939. I agree with these criticisms. They contributed to the production of tanks which were too thin and which had significant areas of stress concentration.

940. Borealis also point to the evidence of low morale at Portadown and of aspects of poor quality control such as the use of welding (the need for which should have been avoided and which is an indication of poor quality levels in production) at Portadown to repair tanks and the fact that many tanks have failed as a result of a poor mismatch at parting lines caused by poor mould maintenance or poor quality control: see paras 565-590 of Nugent 1. Professor Marshall found that in each of the 12 cracked parting lines which he had examined the crack that grew through the tank always started at the root of the corner where there was a mismatch between the two halves of the mould, so that there was a stress concentration.

Pigmentation

941. Pigment acts as a UV filter. Different pigments, of which there are many varieties and combinations, including many varieties and combinations of green, act in different ways, not always beneficially. The same pigment may have a different effect when mixed with different polymers or stabilisers. The effect may differ according to the concentration of the pigment.

942. Ms Fatnes' email of 18 November 2001 recommended that natural Borecene would have an approximate lifetime of 5 years whereas for a 10 year lifetime colours improving UV performance were needed such as green for OFTEC approved tanks.

943. Kingspan, which used a range of pigments, did not carry out, or have available, any tests which analysed the effect of the particular pigments which they used and their pigmentation method on UV performance or the mechanical properties of the pigmented material. This was despite the fact that Ms Fatnes' email of 25 November 2001 indicated that Borealis had not performed any tests on "tank green" pigment, and despite the fact that the pigment was being required to double the lifetime of the natural PE, as was apparent from the 18 November email. Borealis contends that, in those circumstances, the failure of any Borecene tanks after five years cannot be attributable to the UV performance of Borecene as opposed to Kingspan's failure to assess whether the pigments they used were adequate.

944. The absence of test data on the effect of the pigments used by Kingspan, at the concentrations used by them, on the weathering characteristics of the polymer does not establish that the pigments used were inadequate to double the lifetime of the natural polymer. What Borealis can legitimately say is that no testing has been done which eliminated inadequate pigment as a possible cause. Nor has any testing been done to prove its adequacy.

Black pigment

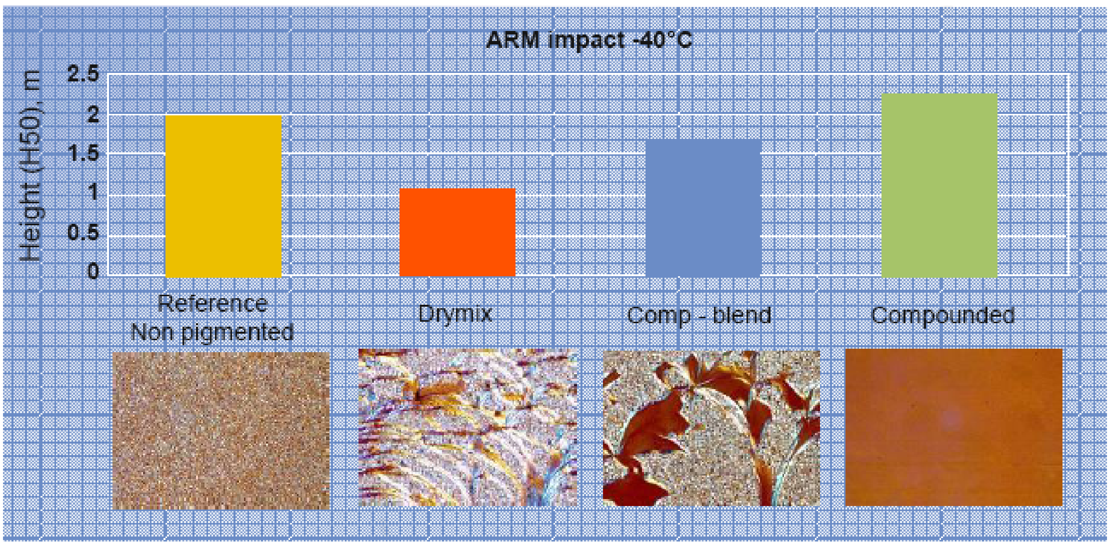
945. Ms Fatnes' recommendation was for black pigment to be used for tanks intended to last in excess of 10 years. Black polymer is a compounded material and offers, as is well known, excellent UV protection as is apparent from the tests: see Series A at paras 194 – 195 above. Mr Wood's evidence was that it was cheaper than green (but I assume that that does not include the cost of compounding). Three out of the four claimants guaranteed their tanks for 10 years and the design life of the tank was between 15 and 20 years. In those circumstances it is perhaps surprising that Kingspan chose to use dry blended green pigment, even though that is very widely used by rotomoulders. Kingspan was giving, on the basis of commercial considerations, a guarantee of 10 years – so that, if the expectation as expressed was fulfilled, there was no safety margin at all.

946. I do not regard it as open to Borealis to say that the effective cause of the increased failures is Kingspan's failure to use black borecene, although it seems to me likely that the use of compounded black pigment would have reduced and possibly eliminated the increased rate of failure. Black was recommended for lifetimes in excess of 10 years. But Borealis never suggested that black material had to be used for lifetimes up to 10 years; and it was well aware that Kingspan, like many others, was using green pigment. I do not regard use of black pigment as an adjustment that Kingspan should have been required to contemplate.

Compounding

947. Compounding is, and was well-known to be, the best, and dry blending the least, satisfactory method of mixing in terms of effect on mechanical properties and UV resistance. Dry blending, being the cheapest, was the most widespread method. But it was well known in the industry not to be ideal.

948. The effect of pigmentation on impact strength is illustrated in figure 114 of Nugent 1, where the vertical axis represent the height from which the weight must be dropped to procure failure:



As can be seen from that figure dry mixing reduces the impact strength (the higher the loading the greater the effect) and compounding actually increases it. In such circumstances it is no surprise to find Professor Marshall and Dr Nugent recommending compounding and counselling against dry mixing. (Professor Marshall's view was that compounding should always be adopted).

949. There are two different methods of dry blending: (a) where the pigment is dry blended with the PE in the mould itself, which rotates at between 4 and 8 rotations per minute; and (b) where the pigment is pre-mixed in a blender before being added to the mould. The blender may be low shear or a high shear turbo mixer. Of these (a), which was the method adopted at Portadown (although there may have been a change in 2003) and Glenamaddy, is the least satisfactory. At Banbridge the colourant was pre-mixed in an automated mixing system which may or may not have been a turbo mixer. Problems with pigment agglomerate are recorded in the Held/Scrap Products files. Carrickmacross had what is described by Mr Morris, the plant manager, as "*a silo which contained a mixing arm*" which may or may not have been a turbo mixer.

950. When Mr Schindler was at Dow he had carried out tests on some Dow material in 1987 and advised Kingspan that the brittle failure revealed at - 20° C was probably due to in-mould blending. Tests on other Dow material in 1998 showed low impact strength at low temperatures which was said to be due to the pigment. Mr Schindler's advice was that it would be better to use a method other than dry blending in the mould; and that compounding was the best.

951. The level of colourant used may affect the strength of the rotomoulded product. In *Rotational Moulding: A Practical Guide* in 2001 Dr Nugent recommended a maximum level of 0.22%. The data from Portadown indicated a considerable increase in the pigment proportion during the main Borecene (RM 8402 and RM 7402) usage. Data on RM 7402, the only material moulded at both the highest and the lowest level of pigment incorporation shows a markedly reduced failure rate in respect of the R 245 when there was a reduction in level. I agree with Dr Nugent that that indicates that the increase in pigment, reducing the strength of the material, was a likely factor in the increase in failures at Portadown, particularly where large agglomerates coincided with thinner wall sections.

952. It was Professor Marshall's evidence that Kingspan's use of dry-blend, as opposed to compounding, pigment reduced the toughness of the Borecene material at critical corners. He observed that the microstructure at corners of Kingspan's tanks, where failures occurred, had a severely compressed transcrystalline structure which prejudicially affected the mechanical properties and crack resistance of the material and encouraged the propagation of cracks along the "*schnitzel*" boundaries.

953. The schnitzel description derives from my judgment in *Balmoral* and is intended to represent the polymer surrounded by a boundary of pigment as a result of dry blending which, essentially, coats the polyethylene particle. Another simile used by Professor Marshall and Dr Nugent was the sugar puff, representing the polymer particles surrounded by pigment at the beginning of the rotomoulding process. Under the effect of stretching of the molten mass in the process, the sugar puffs become schnitzel like in formation. Because the pigment - surrounded polymer crystals grow laterally they are referred to as "transcrystalline" entities. Pigment particles, heterogeneously distributed, are believed to act as nuclei for crystals to form.

954. Because smaller particles of polyethylene adhere to the mould before larger ones (due to their higher surface area to volume ratio) there will be a concentration of schnitzels - with their boundaries of pigment - at the outer surface[118]. The effect of this will increase at corners[119]. Boundaries are weakening features since the pigment and polyethylene are not particles fused into one but separate. Any stress will naturally follow the line of the boundary[120]. Further, if colourant is added directly to the mould it can form agglomerates, themselves weaknesses and possible starting points for failure[121], which are not broken up in the moulding process. As Professor Marshall explained, compounding of pigment would have produced a more homogenous blend of pigment and polyethylene, and would not have resulted in the formation of a "*schnitzel*" structure. Dr Nugent's evidence was to the same effect: see, in particular, Day 38/54[4] – 70[2].

955. Kingspan, like several others, had used the dry blending method of pigment incorporation for many years in the manufacture of ZN tanks which had not failed in anything like the number of Borecene failures. The disadvantages of dry blending apply to ZN as well as Borecene. That suggests that the method of incorporation has no bearing on the *increased* failure of Borecene made tanks.

956. However, the evidence of Professor Marshall and Dr Nugent persuades me that the transcrystallinity (as well as thinness and wall thickness variation) was increased as a result of the increased draining away of material with a lower viscosity from internal, and its accumulation at external, corners, which were themselves the product of a failure to optimise processing parameters or design. As a result weaknesses in processing and design which, to use Professor Marshall's phrase, placed the satisfactory performance of tanks on a "*cliff edge*", led to greatly increased failures when a material with a lower viscosity was used; and the increase in transcrystallinity played a part in the process which led to increased failures.

957. I have not ignored the fact that Borealis' brochures said that good results could be obtained from dry blending. I do not doubt that they could. Whether they would do so would depend on the factors relevant to all rotomoulding: design, wall thickness, wall thickness distribution, optimisation of processing parameters, and pigment choice and concentration. Further this advice, which was of the most general character, cannot absolve the rotomoulder from its responsibility to consider the appropriateness of his method of incorporation having regard to the particular design of his tanks and the effect of his processes on wall thickness and its distribution.

958. Accordingly, as it seems to me, compounding was one of the reasonable adjustments which Kingspan could be expected to consider making as a means of improving the weatherability of the tank. I do not mean thereby that it was imperative for them to have done so. But if they did not, it was necessary to recognize that the most inhomogeneous method of incorporation would afford much lesser protection than other methods so that weaknesses in design or processing would not be compensated by the (known) beneficial effects of compounding.

---

118 The photograph at E 17.100 is an example of this.
119 See the photographs in Dr Nugent's figure 91.
120 For an example of deterioration of a surface at pigment boundaries see Marshall 1, figure 22.
121 See figure 10 of Marshall 2.

Parting Lines

959. Dr Nugent's report records the existence of a number of parting line failures (although the mould which he shows at figure 224 was not in use in 2002-3). The parting line is a heavier section of the mould. It thus acts as a heat sink with the result that material may not build up at the parting line to the same extent as at the surrounding walls and thinning will result. Leakage onto the mould surface can act as an insulating layer reducing heat flow. Leakage may also arise where there is a problem between the fit of the two halves of the mould. As a result flash occurs on the moulded part and there is more thinning at the parting line as material is extruded between the flanges. The flash then has to be trimmed. If that is not done properly a rough edge can result which may act as a crack initiation point. If the two halves of the mould do not correspond exactly a step feature is created. This creates a stress concentration[122] at the parting line which can act as a crack initiation point.

960. Dr Nugent's report provides examples of all these phenomena, including photographs and microscopy images, in relation to both Borecenes and to different rectangular tanks, together with references in such QC log books as remain at Portadown[123] to welding of tanks which had to be carried out at the parting line for 245R and 240R designs because certain areas were thin or split. He points out that there were 2,073 RMA claims for rectangular tanks from all facilities which specifically mentioned parting line failures and these included early failures which were much more likely to be due to a weakness moulded into the tank than exposure to the elements.

961. The extent to which there was thinning at parting lines has not been measured. Kingspan suggests that degradation is the cause of failures at parting lines. It seems to me unlikely that the manufacturing faults, which are apparent from the information in Dr Nugent's report, are not the cause of parting line failures. More relevantly, whilst Borealis cannot be responsible for failures which are so attributable, it is not apparent than the incidence of any such failures was different according to whether the material was ZN or Borecene.

UV testing

962. Although they could have done so (and could have completed 10,000 hours in a WOM between Athlone's approval of RM 8402 in June 1999 and purchases of Borecene in production quantities), Kingspan did not carry out or procure the carrying out of any UV testing of their products, either in the WOM or in the open air until the KIWA tests were requested in late 2001. They did not specify the UV package that they wanted. Nor did they carry out any tests to assess whether 10 years (or 5 years in the case of Rom) was an appropriate period for their guarantees. The 10 year period was not the result of any scientific study or testing but was chosen for commercial reasons in order to compete with the manufacturers of steel tanks. In the case of Rom there was a switch from a 1 year to a 5 year guarantee as a result of a commercial decision.

---

[122] Several factors combine to create this failure, (1) there is often a natural thinning of the cross-section in the area of the parting line, (2) there is a sharp feature or edge which concentrates stress and (3) this sharp feature frequently coincides with a region of high stress (see below).

[123] QC Logbooks covering shifts from 6.9.01 to 29.6.02 and 1.5.03 to 11.5.03 at Portadown. The intervening books are missing. The Department was abolished on 12.5.03. The logbooks contain comments recording a considerable degree of frustration on the part of the QC staff.

963. Borealis submits that the loss claimed in these proceedings flows in large part from Kingspan's decision to give these guarantees without carrying out any testing of their rotomoulded product for UV resistance before they started using it; and not from any failings on the part of Borealis.

964. If I were to conclude that Borecene could not, even with reasonable adjustments, be used to make tanks that lasted 10 years I would not regard Borealis as absolved from liability because Kingspan had not themselves carried out any tests. But Kingspan's failure to UV test its product had a number of consequences.

965. First it lacked the wherewithal to gauge the effect of weathering on its rotomoulded tank; or the problems that might be inherent in using a different material; and how they might be addressed. Second, its decision to "get by" with a letter of conformity meant that it was not in receipt of any warranty that Borecene made tanks would last for 10 years, or tests that showed that Kingspan's Borecene made tanks would do so. What it did have was (i) a letter of conformity, predicated on good manufacturing practice, in relation to 22 GJ/m^2; (ii) an unanswered and unfollowed up request for a letter of conformity in relation to 34 GJ/m^2; and (iii) an email which expressed an opinion as to how long tanks could be expected to last which was said to be without the benefit of testing green pigment and which said that green pigment would be needed for up to 10 years.

966. In those circumstances, while it was a term of the contracts that Borecene was capable of being used to make tanks which would last ten years, there was much that was, or could be, incumbent on Kingspan to do (in terms of testing, inspection and, if necessary, modification) in order to secure that result.

Flame polishing

967. Kingspan used gas-fuelled torches to "flame polish" tanks after demoulding so as to create a pleasing finish. The process is relatively uncontrolled since its effect depends on how close the operator gets to the tank, the degree of flame, and how long he positions the torch in any one place. That that is so is apparent from the still photographs from a video showing Mr Carey, Titan's quality and processing manager, polishing a tank at what he thought was at least a foot distant, but in fact was closer. As a result very considerable heat (280-350°C) can be concentrated at or near to the corners on the tank, which were areas of weakness and of localised degradation.

968. The video showed that flame flaring and reflection occurred at the corners. Professor Marshall expressed the view that any such flaring and reflection is likely to have given rise to a greater degree of degradation in those areas caused by the extra heat applied to the tank surfaces. Mr Carey accepted that the video showed that he applied approximately three times as much heat to the upper surface as the lower part of the tank. It was Mr Scotson's evidence that at GSP they did not flame polish the tank as much at the bottom of the tanks. The location of cracking is mostly at corners on the tops of tanks.

969. Experiments carried out by Borealis' experts (and in particular, FTIR ATR analysis[124]) on flamed and unflamed RM 8403 tanks (recorded at E19/76-104) show

[124] Fourier Transform Infrared Attenuated Total Reflectance.

that flame polishing can oxidise a thin surface layer of the tanks. The changes to the microstructure caused by torching are illustrated in figures 82 and 83 of Marshall 1. This, in Professor Malatesta's opinion, results in the formation of active carbonyl groups that promote oxidative degradation during the service lifetime of the tank. Dr Botkin agreed that the FTIR results for flame polished samples provided some evidence that flame polishing has an effect on the outer surface layer of the tanks. He also agreed that, on the premise that these tests were representative of the way flame-polishing was performed by Kingspan, they showed that flame polishing changed the surface of the tank. He acknowledged flame polishing to be a "*possible factor*" in the failure of the tanks.

970. Accordingly, so Borealis submits, Kingspan are likely to have accelerated the degradation process, particularly in isolated areas of the tanks close to corners where the heat from the flame is likely to have been concentrated (and where many of the tanks eventually failed).

971. Kingspan points out that the tank which was the subject of analysis was unidentified and there was only one. They also refer to a study in the Plastics Additives Handbook on Photo-Oxidation of Polyolefins which states that carbonyl groups seem to have only a small oxidation initiating efficiency.

972. I regard flame polishing as of limited relevance. It is not, by itself, a realistic explanation of the increased failure rate of Borecene as opposed to ZN tanks. Abandoning flame polishing does not seem to me to have been the sort of adjustment that Kingspan should have considered adopting. In his evidence in the Balmoral case Mr Halvorsen said in terms that flaming was a common practice and he would make no particular criticism of Balmoral for making use of that practice from time to time. There is nothing to suggest that Kingspan should have regarded Borecene as particularly susceptible to its effects; or that flaming would be detrimental to Borecene in a way which did not apply to ZN material[125]; or that flame polishing was carried out in relation to Borecene made tanks in any different way to ZN ones. It may be that flame polishing played a part in promoting oxidative degradation; and, if it did, it was not something for which Borealis was responsible. But the effective cause of the increased failures lies elsewhere.

Conclusions

973. It is now necessary to step back from this plethora of material, which does not all point in the same direction, and state the conclusions which I draw from it.

974. I do not regard it as established that Borecene could not, even with reasonable adaptions and adjustments, have been used to make satisfactory green pigmented tanks which would last 10 years, or that such an unfitness for purpose was the, or an, effective cause of the increased failures of Borecene tanks.

975. I have reached that conclusion in the light of:

[125] Professor Marshall observed that Borecene required more heat to melt and that the melt appeared to move more significantly with Borecene than ZN but it is not apparent to me from that evidence that the difference was significant for present purposes.

a) the pattern of failure of tanks made by Kingspan with Borecene; as well as the absence of complaint of inadequate UV resistance in other cases;

b) my view of the technical evidence; and

c) a consideration of the other causes and factors postulated in paras 883 - 972.

976. As to a) the relevant considerations are (i) the number of tanks that have not failed; (ii) the extent of failures in the early years followed by a marked falling off in failures thereafter; (iii) the variation in failure rates as between different factories and different designs; and (iv) the factors set out in para 708 (i) – (vi) and 747 - 754, which individually and, even more so in combination, seem to me to make inadequate UV resistance on the part of Borecene an unlikely explanation of the cause of increased failures.

977. As to b) I am not persuaded that Ms Takacs' viscosity data or Professor Spoormaker's bending tests or Professor Williams' SNC tests, provide an adequate basis for concluding that Borecene had, either as an intrinsic characteristic or on account of inadequate stabiliser, or both, an inherent deficiency in weather resistance compared with ZN material such as would satisfactorily explain the greatly increased Borecene failures.

978. On the contrary it seems to me likely that Borecene could have been used to make satisfactory tanks, and that the failure of Borecene made tanks in increased numbers could have been eliminated or avoided to a very large extent if Kingspan had done one or more of the following: (a) adapted their sharp and angular designs; (b) adjusted their shot weights; (c) adjusted their processing parameters; (d) changed their method of pigment incorporation; and (e) improved their quality controls so as, amongst other things, (i) to increase wall thickness, where needed, and avoid excessive thinness; (ii) to prevent shear thinning at inner, and build up at external, corners; and (iii) to rectify excessive wall thickness variations[126].

979. Borecene with its increased flow properties (which in several respects are an advantage) highlighted deficiencies in Kingspan's designs and processes in circumstances where the designs were already close to the limit[127] in terms of wall thickness and stress concentration, the extent of failure varying from factory to factory and design to design. The problems for rotomoulding purposes inherent in the design of the tanks and Kingspan's processes produced more significant effects with a material of lower viscosity. This was Dr Nugent's view and I accept it.

980. It is common ground that wall thickness is an important factor affecting the strength of a tank and, in particular its UV resistance; and that higher stresses generated by wall thickness variation will increase UV degradation. I accept the views of Dr Nugent and Professor Marshall that excessive thinness of walls and wall thickness

[126] That exercise was something which Rom did do in respect of Resilin 8504: see Mr Kelly's letter of 7 January 1999 to Dr McDaid.

[127] i.e. the limit beyond which the manufacture of satisfactory tanks was either impossible or very difficult because the tanks could not withstand the stresses encountered in service. Mr Campbell described them as a "failure waiting to happen".

variations were major factors in causing the failure of Kingspan's tanks. The data analysed by Dr Nugent showed a correlation between wall thickness variation and failure. The figures set out in table 11 of Marshall 2 are a guide to how tensile stress increases proportionately to reduced thickness and the marked effect of reducing thickness.

981. UV, which modifies molecular structure and promotes oxidation, played a significant role in the failures. Insofar as the degradation which led to failure arose from oxidation caused by UV, the failure would not have occurred "but for" UV. That does not mean that Borecene was unfit for use or that such unfitness was the effective cause of the increased failures. UV is a fact of life. All polyethylenes degrade under its effect (and that of heat and moisture) which leads to oxidation. (The ZN made tanks did so and in the same way as the Borecene ones). The fact that they do so is not of itself a defect. Inevitably, most oxidation from UV will arise on the exterior.

982. Oxidation is not the same as, although it may lead to, cracking or failure. Whether and to what extent it does will depend, inter alia, on the extent of the oxidation. Professor Malatesta's view, which I think likely to be correct, is that cracking can occur even when oxidation is minimal if the stress is substantial enough. Per contra the fact that a part is heavily oxidised does not necessarily mean that it is going to fail[128]. Stress, which is the equivalent of providing energy, increases the rate of oxidation and the risk of a crack beginning and, if it does begin, of its propagating to failure. Increasing the stress increases the likelihood. A constant cycle of heating (when the thinner sections will get hotter than the rest and therefore expand at a different rate) and cooling (when the tank may not fully recover because the fluid keeps it under tension) can create stresses which cause failure.

983. In the present case the likelihood, as it seems to me, is that a combination of poor or problematic design (from a rotomoulding point of view) coupled with a failure to make the adjustments referred to in para 922 produced excessive thinness and excessive thickness variation. This produced increased stresses and stress hotspots which led to increased oxidation and increased cracking failure.

984. As to processing parameters, Dr Nugent's evidence, which I found convincing, was that by controlling the oven temperature and cycle time and thus the PIAT, Kingspan could control the final viscosity of the material (ensuring that there was not too much flow over sharp features) and by controlling the early cooling Kingspan could prevent the material becoming too fluid. It could also influence the movement of the material by controlling the rotation ratios and rotation speeds, and so move material to specific areas on the mould, thereby improving wall thickness distribution. It could use insulation or air movers selectively to move material to, or remove it from, particular areas[129]. In any event it would have been possible to increase shot weights.

985. I do not regard the trials carried out by Professor Harkin-Jones on the effect of changes in various processing parameters (e.g. rotation speed, plate speed, oven time, PIAT and rotation ratio) on thickness distribution as establishing that changes in

[128]Nugent 1, para 646 has photographs of a tank with classic signs of UV degradation and with hairline fractures which was working perfectly.
[129] Dr Nugent's preferred solution would have been more rounded designs. But in his view adjustment to rotation settings, mould shielding and processing temperatures would have improved wall thickness distribution. See Nugent 1:15 and 661-2.

processing parameters would not enable Kingspan to make adjustments which would allow the satisfactory production of tanks. These trials were limited in scope and the comparisons were made with relatively few data points. She used two moulds, one primarily for 8402 and one primarily for 7402 on the same machine. In reality the processing conditions - with different moulds and machines - would have been more varied than those applicable to the trials, and the results from actual production more varied. She looked at, inter alia, 3 different oven temperatures and 3 different PIATs and at the effect of altering individual factors in isolation but not in combination. The Rotolog traces relating to the trials have not been produced (for the significance of which see Nugent 2 para 93). She herself declined to attend to be cross examined.

986. Dr Nugent did not regard Professor Harkin-Jones' work as establishing that a change of settings would make no effective difference. Neither do I. He indicated the wider range of possible permutations which, from a rotomoulder's point of view, he would have adopted: see Day 38/98 [22] – 101 [11].

987. The factors that caused or contributed to failure were varied and can be expressed in different ways. A tank with an angular design which fails because excessive and undetected wall thinness and wall thickness variations, particularly at corners, have caused the generation of stresses which have led to cracking may be regarded as having failed as a result of (i) its design (because a softer design would have avoided the variation); or (ii) its inadequate shot weight (because with a greater thickness the variation would not have mattered); or (iii) poor processing and quality control (because if the resulting wall thicknesses had been properly checked steps would and could have been taken to avoid excessive thinness or thickness variations); or (iv) poor pigment or pigment incorporation, which, particularly in the case of dry blending in the mould may have contributed to the weakness of the tank.

988. It is not feasible for Borealis, much less the Court, to specify precisely, in respect of each tank, or each combination of tanks, that failed, what factor or combination of factors was the cause of failure or what adjustments were necessary, or would have been appropriate, to avert, and what factors were responsible for its failure. In general Borecene made tanks failed to a much greater extent than ZN tanks because Kingspan failed to adapt or alter their designs and/or processes in a manner appropriate to a new material of lower viscosity and different properties – characteristics which were differences but not defects – which adaptation/alteration was necessary, having regard to the problems inherent in those designs and processes and the known characteristics of a new material.

989. Tanks can be successfully rotomoulded by several different combinations of design, material (including pigment and method of pigment incorporation) and processing. There are a limited number of absolute requirements. If and insofar as any particular feature of design, processing, pigment or method of pigment incorporation cannot be, or is not to be, changed, changes may be needed in respect of others. If a change is to be made, what exactly is needed depends in part on what the rotomoulder insists on keeping. It is not necessary to be prescriptive as to the parameters which are to be changed. What can, however, be said in the present case is that an increase in thickness/shot weight was needed to ensure thicknesses in line with the design

standard and that such an increase was, as Dr Nugent put it, *"an immediate solution"*[130].

990. One possible adjustment would have been the use of black (compounded) pigment (as recommended by Ms Fatnes for tanks intended to last for more than 10 years). Kingspan had used compounded black Borecene with MFR 6 to make small water cisterns and small fuel tanks for vehicles. However, as I have already said it seems to me that the contractual requirement was that Borecene be suitable for use in making tanks with green pigment. I would not regard the contractual requirement as met if the *only* way of making satisfactory tanks was by the use of black pigment.

991. Another adjustment would have been to use compounded material (well known to be the best method of dispersion of the pigment and likely to produce better mechanical properties) rather than dry blending. Both Dr Nugent and Professor Marshall would have advocated compounding, the process of which was explained at Day 36/51 ff. Professor Marshall's view was that the use of the dry blending method of pigmentation was a major factor in the difference in performance of Borecene and ZN and very severely affected the mechanical properties and crack resistance of Borecene. I would regard compounding as a reasonable adjustment that could have been made.

992. As it was, Kingspan continued with the same designs. They used on the shop floor a minimum wall thickness of 4.5 mm which was lower than the design thickness and derived from an OFTEC minimum which related to permeation. As a result the shot weights were too low. As the Schindler data spread sheets show tanks were often produced with areas of wall thickness below, sometimes well below, 4.5 mm. They had inadequate checks (including in particular destructive testing and checking of thicknesses at corners and changes in profile) as to the wall thicknesses, which were in many instances too thin, and as to the wall thickness variations being created, which were in many instances too great. Had they carried out the necessary checks, they should have discovered the need for changes and adjustments. They used the least homogeneous method of pigment incorporation with pigments whose UV weatherability characteristics are uncertain. In my judgement, even if it is to be assumed that the pigment would be dry blended, it was possible to make satisfactory tanks by other reasonable adjustments.

Time Bar Danish Law

993. Articles 39 and 40 of the CISG provides as follows:

> *"39*
>
> *(1) The buyer loses the right to rely on a lack of conformity of the goods if he does not give notice to the seller specifying the nature of the lack of conformity within a reasonable time after he has discovered it or ought to have discovered it.*

[130] His report shows a reduction in average thicknesses in all designs before the introduction of Borecene followed by an increase after it ceased to be used; and his analysis of production records shows both Titan (in respect of the R 1225 and H 1300 tanks) and Tyrell (in respect of the R 245 tank) increasing shot weights after they stopped using Borecene: 1: 4.4.6.1-2. It also shows that tanks at ROM and GSP tended to be heavier than similar tanks elsewhere.

(2) In any event the buyer loses the right to rely on a lack of conformity of the goods if he does not give the seller notice thereof within the period of two years from the date on which the goods were actually handed over to the buyer, unless this time-limit is inconsistent with a contractual guarantee.

40 The seller is not entitled to rely on the provisions of articles 38 and 39 if the lack of conformity relates to facts of which he knew or could not have been unaware and which he did not disclose to the buyer."

994. Notice under Article 39 does not have to be in any particular form and may be given orally. Failure to give notice within the time limits stipulated by Article 39 bars the buyer from pursuing any claim against the seller in respect of the alleged non conformity whether or not the buyer has then suffered loss thereby. The 2 year period, which begins on the date of delivery of the goods, is applied strictly. Subject always to Article 40 the buyer loses his right to rely on a lack of conformity even in respect of a non conformity which was not detected by the buyer after reasonable examination or one which was not capable of detection. If, therefore, the defect in question is a latent defect the buyer may have the whole of the 2 year period in which to give notice - but not beyond.

995. Kingspan contends that the defects in the present case were latent defects such that it had until the expiry of the 2 year period in the case of each delivery in which to give notice.

996. The experts are agreed that a notice should provide all relevant information and, consequently, that a notice should inter alia (i) identify whether and to what extent the buyer relies on non-conforming delivery; (ii) specify the nature of the specific non-conformity in terms of quality and/or quantity in relation to the terms of the contract and (iii) include the results of any examination of the goods that the buyer has performed. At the same time the buyer cannot be required to make disproportionate efforts to provide relevant information.

997. The degree of specificity required for the notice is influenced by the degree of expertise of the buyer and the fact that the buyer has processed the raw material and turned it into a different product. Greater specificity would be expected from an expert than an average consumer and, also, from someone who has processed the material since, in the latter case, the buyer's knowledge of the final product will be better than that of the seller and the buyer will be expected to have some knowledge of the unprocessed product in order to be able to process it.

Notifying symptoms

998. A critical question is whether it is sufficient for a notice to state the symptoms of any problem rather than the cause. Mr Bierfreund accepted in evidence that it would be sufficient for the buyer to notify the symptom so long as it was in fact connected to the actual defect such that it would suffice for a buyer to say that he was experiencing cracking failures in order to recover in respect of a defect which had in fact caused those failures.

Borealis' submissions

999. Borealis submits that this evidence was of limited relevance. In the ***GMS Modules*** case decided in the District Court in Zug on 30 August 2007, to which Mr Bierfreund had been referred in the course of his evidence, the defective goods were electronic cards containing certain components and software applications, used as an integrated part in devices for the transmission and reception of data by wireless communications. The buyer used the cards, without alteration, as components of mobile phones. The goods in question were thus, it is submitted, not comparable to a raw material that is processed and altered by the buyer to make an end product. In that case, the defect was in the goods supplied by the sellers themselves, not the final product (and was apparent in the goods before they had even been integrated into the mobile phones). The Court was not required to consider, and did not consider, a situation in which a raw material has been altered in the process of incorporation into a final product and where it was the final product, rather than the material sold, which experienced failure.

1000. In that case the Court said:

> *"The requirement that the nature of the lack of conformity be specified is intended to put the seller in a position to understand the asserted lack of conformity and to take the necessary steps to gather any required evidence for possible future legal proceedings about the question of conformity, to initiate either a substitute delivery or a repair of the goods, and finally to take recourse against its own supplier. On the other hand, the required standard for the specification of the lack of conformity must not be set too high. In order to describe the duty of the buyer, a standard of both objective and subjective elements must be applied. This standard takes the positions of both the buyer and the seller in their commercial transaction into account, any possible cultural differences as well as, in particular, the name of the goods. Possibly, an expert can be expected to give a more specific account of a lack of conformity than a layman. Under the CISG, any general complaints ("not alright", "inadequate characteristics", "wrong delivery", "poor quality", "bad construction") as well as any general statements of dissatisfaction ("not according to our expectations") are clearly insufficient notices. The buyer will be expected to identify whether and to which extent he relies on an insufficient delivery, which specific deviations in terms of quality are complained about, and in what respect the delivered goods form a mere aliud compared with the goods owed under the contract. If the buyer has carried out an examination of the goods, he will have to inform the seller about the main results. However, in case of machinery and technical equipment, the buyer can only be expected to give an account of the symptoms but not of their respective causes. The notification does not require any specific form, so that a notification over the telephone may be appropriate. With regard to the applicable time limit, the circumstances of the individual cases must be considered, including any trade usages and established practices between the parties. If the buyer wants to keep the goods and merely claim damages or claim a reduction of the purchase price, the time limit may be longer compared with a case where the buyer seeks to reject the goods. Since a variety of different opinions exists with respect to the question of a "reasonable time" throughout the Contracting States of the CISG, a rough average duration of one month should be assumed. The period commences as*

soon as the buyer has become aware of the lack of conformity of the goods (cf. Schlechtriem, Kommentar zum einheitlichen UN-Kaufrecht, 3rd ed., Munich 2000, Art. 39 margin number 6 et seq.).”

1001. The observation that “*the buyer can only be expected to give an account of the symptoms but not of their respective causes*” relied upon by Kingspan was directed at cases involving machinery and technical equipment. There is no warrant for extending it beyond this specific class of goods. Raw materials are not analogous to complicated machinery. Further, the decision of the Court did not depend on the observation. The Court found that no adequate notice had been given and dismissed the buyer’s case on that basis. The reference to symptoms in the judgment was therefore *obiter* (and, in any event, there is no formal system of precedent in the context of the CISG).

1002. In the course of his evidence Mr Bierfreund was also asked to consider the example of a watch which goes wrong because of some unexplained defect. He indicated that it would be acceptable for a customer to give notice that his watch did not work for reasons which the customer could not explain. Borealis submits that that, too, is not a good analogy for the present case, since it does not take account of the fact that what was sold in the present case was a raw material whereas the object which showed symptoms of failure was Kingspan’s finished product. A more appropriate analogy would be a buyer who purchased one cog to manufacture a watch. In such circumstances, it would not be sufficient notice of non-conformity of the cog to report that the watch was not working.[131] Further, the watch example involves a lay buyer with no relevant expertise. In this case, the performance of Kingspan’s tanks was dependent on a range of factors, only one of which was the raw material (and all of the rest of which were solely in their control). There is no necessary or even probable inference from the fact of tank failure that there is anything wrong with the raw material. In those circumstances, simply stating that tanks are cracking or failing cannot be regarded as an adequate or sufficiently specific notice in respect of non-conformity of the raw material. None of the examples put to Bierfreund, and none of the evidence he gave in response, went to this question. Rather, the common evidence of the Danish law experts that it is necessary to identify the specific non-conformity for a valid notice to be given continues to apply to the present case.

1003. Article 39 (2) operates – as is common ground – to deprive a buyer of a right to rely on non-conformity even when the defect is latent and undiscoverable. It provides an absolute cut-off beyond which nonconformities cannot be advanced. It would be inconsistent with this aim to water down the requirement that the nature of the non conformity be specified. This would enable the buyer to notify symptoms that might have nothing to do with the product sold in circumstances where the seller was unable to understand what non conformity was being alleged and to take the necessary steps to gather any evidence needed for legal proceedings.

Conclusion

[131] Even then, the degree of precision of the notice required from such a buyer would still be less than for a user of a raw material, because the cog would not have been physically altered in the process of making the watch, in contrast to the raw material in the present case. A closer analogy might therefore be with a buyer who purchased metal with which to make a cog for a watch.

1004. Whilst I see the force of these submissions I do not wholly agree with them. Article 39 applies in relation to latent defects. It must, therefore, be possible to give a notice in respect of such defects. The nature of the notice required in such a case must necessarily be affected by the fact that the defect is a latent one, about which it may not be possible to say more than that the product has failed because of some defect in the material, the exact nature of which is not apparent.

1005. I consider that a notice would be sufficient if (a) it indicated that tanks were cracking prematurely on account of a deficiency in the raw material which caused them to do so and (b) it was recognisable as a notice of non conformity. I do not mean by the latter that a notice must be so described. But it must be apparent that it is contended that the goods supplied did not comply with the contract. Mr Bierfreund's evidence was, in my view, substantially correct.

1006. Borealis contends that Kingspan failed at any time to give adequate notice of the alleged lack of conformity either within a reasonable time or within 2 years of the date of delivery. Borecene was delivered to the claimants on various dates which are set out in Appendix 4 to Borealis' opening. The first and last dates are set out in the following table:

Claimant	RM8402 deliveries	RM7402 deliveries
1. Kingspan Environmental Limited	23.01.02 to 09.10.02	11.10.02 to 02.09.03
2. Tyrrell Tanks Limited	14.09.01 to 04.07.02	14.02.03 to 16.09.03
3. ROM Plastics Limited	15.02.02 to 25.10.02	15.11.02 to 30.06.03
4. Titan Environmental Limited	11.03.02 to 28.03.02	15.01.03 to 12.09.03

1007. Accordingly the 2 year period expired at various dates between 14 September 2003 and 16 September 2005.

1008. Since I have found that the goods supplied were not non- conforming any decision as to whether notice of the nature of the lack of conformity or knowledge of facts relating thereto will necessarily be obiter. There is a degree of artificiality in deciding, in the alternative, whether appropriate notice was given of that which I have found not to exist.

1009. Lack of conformity in the present case would consist of Borecene RM 8402 and RM 7402 not being capable, even with reasonable adjustments, of being used to rotomould satisfactory tanks in the sense which I have described, such lack of conformity arising from an inadequate resistance to UV weathering as a result either of an inherent characteristic of the polymer or an inadequate stabiliser or a combination of the two.

Notice

1010. Kingspan relies on two events as constituting notice. The first is the letter to Borealis UK of 30 or 31 October 2002[132] signed by Mr Rusk and sent by Kingspan

[132] There are two copies in the papers, one with 30.10.02 in manuscript and the other with 31.10.02 stamped on it. The latter may be the received copy with the date of receipt.

Environmental Containers Ltd. The second is what was said at a meeting between Noel Crowe and Peter Johnston on behalf of Kingspan and David Rolph and Bob Wood of Borealis on 19 January 2005.

The letter of 30 October 2002

1011. The letter is summarised and partly quoted at paras 357- 8 above. It relates to RM 8402 (it is headed "*Re: UV performance of RM 8402*") and cannot be regarded as a notice of lack of conformity in respect of RM 7402.

1012. So far as RM 8402 is concerned, the gist of the letter was:

i) to express alarm at the KIWA UV test which showed that RM 8402 was unlikely to satisfy the prEN 13341 standard;

ii) to complain that Borecene had substantially lower protection than the industry benchmark of UV 8[133] "*which is widely accepted as being the standard in Europe for outdoor products, particularly when considering the European market. This raises great concern about the suitability of RM 8402 for Kingspan products, the vast majority of which are located outdoors and guaranteed for 10 years*";

iii) to complain that the test results indicated that RM 8402 would not pass the UV tests in the European standard and would not therefore be suitable for use in oil tanks and also invalidated the OFTEC approval; and

iv) to say that the problem had implications on the long term performance of products manufactured within the Kingspan Group and that all future supplies would be put on hold until a satisfactory response was received.

1013. I do not regard the complaint that RM 8402 was unlikely to satisfy the prEN standard and that it had a lower protection than UV 8 as, by themselves, sufficient notice of the non conformity now in issue. That non conformity is that Borecene could not be used to manufacture tanks which would survive for 10 years in Northern Europe. It was not a contractual requirement that the material would be UV 8 or comply with the prEN standard. But the letter also complained that the alleged failure to comply with UV 8 "*raises great concern about the suitability of RM 8402 for Kingspan products, the vast majority of which are located outdoors and guaranteed for 10 years".*

1014. In my judgement the letter is just sufficient to amount to notice of non conformity in respect of RM 8402. Kingspan was saying that, in the light of the test, and the apparent non compliance with the prEN standard and the OFTEC Standard, (the former of which referred originally to 10 years and the latter of which had referred to 900 Kly), it was greatly concerned that RM 8402 was not suitable for products located outdoors and guaranteed for 10 years. In stating that Kingspan was giving notice that RM 8402 appeared to be unsuitable for that purpose. I do not regard the fact that the letter was expressed in terms of great concern about suitability, rather than a stark allegation of unsuitability, as disqualifying it as a notice of non conformity,

133 Dr McDaid agreed that there was really no industry benchmark: different suppliers had different additives.

particularly in the light of the fact that only time would tell whether tanks would last 10 years. The concern must obviously have been that Borecene was unsuitable.

1015. It is not apparent to me that notice of non conformity should have been given at any time earlier than October 2002. Accordingly I do not regard Kingspan as time barred under Danish law in respect of RM 8402.

The 19 January 2005 meeting

1016. What happened at this meeting cannot be relied on as timely notice in respect of any of the RM 8402 deliveries because the last of them occurred more than two years before. Nor can it be relied on in respect of those deliveries of RM 7402 which took place prior to 19 January 2003 of which there were several.

1017. At the meeting Mr Crowe and Mr Johnston told Borealis that, as far as Kingspan was concerned, the Borecene supplied by Borealis (of both kinds) was defective and not suitable for the manufacture of rotomoulded tanks. They made clear that they were experiencing cracked tanks and they were blaming this on Borecene. Mr Wood understood that there was a complaint. Mr Crowe said that around 100,000 KEC tanks may be at risk of failure and that significant numbers had already been replaced in 2004. He asked about the question of liability[134]. Mr Rolph of Borealis did not admit that there was any defect in Borecene but said that he was open to sorting the problem out commercially but that that could not be done in isolation to the Balmoral dispute. Kingspan did not tell Borealis what they thought was wrong with Borecene or mention UV resistance as a problem.

1018. After the meeting Kingspan's complaint was logged in the following terms:

> *"Notification*
>
> *Description cracking oil tanks*
>
> *Complaint is related to cracking oil tanks reported by several customer[s] of the producers linked to the Kingspan Group. [Each of the Claimants was then listed].*
>
> *This case was discussed during a customer visit to Mechelen between Borealis Manag[e]ment and customer.*
>
> *The handling of the complaint is linked to other complaints in the system:*
>
> *QN20001344*
>
> [This was Balmoral's complaint re. cracking oil tanks].
>
> *QN200017872*
>
> [This was a complaint by Carbery Plastics re. cracking oil tanks].

[134] See Mr Johnston's manuscript note: "*NC mentioned the "L" word Liability*".

> *All 3 complaints are being reported to insurance and are to be seen [as] part of this insurance file."*

1019. What was said on 19 January 2005 seems to me to amount to sufficient notice of non conformity. It was a complaint of the symptom – cracking – which was attributed to a breach of contractual requirements by Borealis. It does not seem to me fatal to the validity of such a notice that the causative mechanism was not specified.

Conclusion

1020. Accordingly there was no failure to comply with the Danish law time bar in respect of RM 7402, save in relation to those deliveries which took place before 19 January 2003. In respect of such deliveries the requisite notice was not given and, subject to Article 40, any claim in respect of them, whether in contract or tort, is, in Danish Law, time barred.

Article 40

1021. In order to avoid the effect of Article 39 Article 40 in effect requires proof of knowledge of non conformity. It also applies where the lack of conformity relates to facts of which the seller could not have been unaware. That is, as it seems to me, an expression of a basis for deciding that the seller was in fact aware. If the facts are such that the seller could not have been unaware of them, then of them he must have been aware. That conclusion is consistent with the agreement between the experts contained in the joint memorandum that the seller will only have the relevant knowledge if "*he knew or where his knowledge of the defect reasonably can be inferred, if not proven, from the circumstances in the particular case*".

1022. If I am wrong about that (there is a dispute in the legal literature as to whether the test is subjective or objective and Mr Madsen's evidence at one point suggested that something less than actual knowledge would suffice) then the test may be regarded as embracing wilful blindness to the obvious (insofar as that is different from actual knowledge[135]) and knowledge of facts which would cause any reasonable person to be aware such that it would be grossly negligent not to realise what they signified.

1023. The experts are agreed that the relevant time for assessing whether or not the seller was aware of the facts to which the lack of conformity related is the expiry of the period within which the buyer was required to give notice, being either the expiry of the reasonable time for giving notice under Article 39 (1) or the expiry of the two year period under Article 39 (2).

1024. On my findings there was no lack of conformity for Borealis to know, shut its eyes to, or negligently fail to comprehend.

1025. In those circumstances there is an even higher degree of artificiality in deciding, in the alternative, whether any lack of conformity (if, contrary to my view, it existed) relates to facts which Borealis knew, particularly when my findings on conformity derive in part from the evidence given by Borealis which relates to that question. I propose, therefore, to deal with the matter shortly.

---

[135] Thus, when at the battle of Copenhagen Nelson saw no signal through the telescope placed to his blind eye, it was not for want of knowledge of what the signal said.

1026. Kingspan observes that it is not necessary for Borealis to have known of the lack of conformity as opposed to facts which relate to the lack of conformity. In the present case those facts were, it submits, that tanks made from Borecene were cracking.

1027. That wording begs the question as to the degree of relation that needs to be established. As to that it seems to me that the facts of which the seller must have had knowledge must be such as would indicate to him the lack of conformity in question.

1028. Such an analysis fits with the structure and purpose of the Articles. Under Article 39 what is required is a notice of non conformity i.e. a complaint that the goods are non conforming (which may lead the seller to investigate its validity). Article 39 is intended to produce an absolute cut-off date beyond which claims are not possible even in the case of latent defects. Article 40 is a safeguard to the buyer precluding the seller from relying on want of notice. It is, as Mr Madsen observed, intended to be of very narrow application, where the seller must have been, or come close to, acting in bad faith in hiding latent defects. In that context it would make little sense for Article 40 to apply once the seller was aware of facts which were indirectly related to, or which did not clearly demonstrate, the non conformity in question. Such a construction could mean that the seller was caught by Article 40 even if he was unaware and justifiably unaware of it.

1029. In this respect it is not, in my judgement sufficient, for Borealis to have known that Borecene made tanks were cracking in large numbers. That might or might not have been because of a lack of conformity.

1030. Kingspan relies, inter alia, on the following matters as constituting or evidencing the necessary knowledge:

a) By July 2001 Borealis were aware that DESO had problems with cracking tanks manufactured with RM 8402;

b) By the end of 2001 Borealis were aware that Balmoral was reporting a large increase in static oil tank failures. In September/October 2002 the Defendants prepared an internal document stating as follows [see para 337 above]:

> "*End 2001 reported large increase in number of static oil tank failures mostly horizontal but some vertical.*
>
> *Initially limited to Balmoral, but indicators of failures at other produce[r]s…*
>
> *Is Borecene RM8402 fit for purpose?*
>
> *UV – is the amount we add sufficient for 10 years outside in Europe?*"

In September 2002 the Defendants had also received a complaint from a company called Rotec regarding the cracking of tanks made from Borecene;

c) In October 2002 the Defendants received the KIWA results which showed poor elongation to break results;

d) In October 2002 Mr Wood had requested that all deliveries of RM 8402 be stopped "*due to the fear of problems with the tanks after production/use (ref problems/big claim from Balmoral)*";

e) On 24th October 2002 Mr Halvorsen stated that Borealis was conducting tests to investigate the cracking problem, and had brought in a "crack" expert; and

f) By 2002 the Defendants knew that RM 8402 had been sold on the basis that it was suitable for use in the manufacture of external oil tanks and was "*fully UV stabilised*" even though (i) it had not done any tests to determine whether RM 8402 was suitable for use in the manufacture of external oil tanks, (ii) it had not done any long term testing on the UV stability of RM 8402, and (iii) it had reduced the UV package in RM 8402.

Conclusion on Article 40

1031. I do not regard these matters as sufficient to establish knowledge within Article 40. The cracking at DESO, Balmoral and Rotec was never suggested to have had anything to do with intrinsically inadequate resistance to UV. In the case of Balmoral it was, as I found, not the result of any deficiency of Borecene but of poor rotomoulding practices. The cracking at DESO appeared to Mr Wood to have been largely the result of a mismatch of flanges around the window of the slim line tank and the removal of flash with a knife which had introduced notches on the top surface; and in vertical tanks the cracking had occurred when the wall thicknesses varied between 2mm and 15mm. Borealis' view was that the problems experienced by Balmoral and DESO were not problems with the raw material but problems of poor processing and pigmentation practices.

1032. The fact that deliveries of RM 8402 were stopped does not show knowledge of the non conformity now alleged. The KIWA tests did not show the relevant non conformity. The message from Mr Halvorsen in October 2002 related to the cracking problem at Balmoral. As to (f) it is true that the UV package in RM 8402 had been reduced in terms of ppm from that applicable to Tinuvin 622 but that did not indicate non conformity. I do not accept that Borealis had done no tests to determine whether RM 8402 was suitable for use in the manufacture of external oil tanks and no long term testing on its UV stability. The extent of its testing is as set out in this judgment.

1033. Further, whilst inadequate UV resistance was considered by Borealis as a possible cause of cracking it was something which they (and Balmoral) rejected at an early stage of the Balmoral complaint; and it was not the basis of any complaint except that of Kingspan. In those circumstances Kingspan cannot establish that Borealis knew of facts relating to the non conformity of which they complain.

Irish law time bar

1034. In considering the submissions of the parties in respect of a time bar under Irish Law I have been assisted by the expert evidence of Mr Maurice Collins, S.C. for Kingspan and Mr Denis McDonald S.C. for Borealis.

1035. Kingspan originally commenced proceedings in Northern Ireland and the Republic of Ireland. In May 2009 Kingspan and Borealis agreed that fresh proceedings should be begun in the Commercial Court in London and that all the claims should be heard together. They also agreed that, for limitation purposes, such proceedings should be deemed to have been commenced on the date that the original proceedings were "*validly commenced*" in the two jurisdictions.

1036. Borealis contends that the majority of the claims by ROM and GSP are statute barred because the proceedings in the ROI were not validly commenced and the present proceedings were begun after the expiry of the limitation period.

1037. There is no dispute as to the following:

a) ROM and GSP issued proceedings on 12 November 2007 in ROI before the expiry of all applicable limitation periods;

b) Those proceedings were valid for 12 months so that they could have been served at any time before the expiry of 12 months;

c) Borealis nominated solicitors – O'Hare, O'Connor Walshe - to accept service of the proceedings;

d) The proceedings were served on the solicitors at the address they had given for service within the 12 months, namely on 3 November 2008;

e) On 11 November 2008 Borealis' solicitors returned the Plenary Summons to the Plaintiffs' solicitors indicating that the Summons was defective and that no appearance would be entered in response. The letter suggested that fresh proceedings should be issued;

f) The parties discussed the possibility of a transfer to the Commercial Court which resulted in the agreement contained in a letter from Arthur Cox dated 1 May 2009;

g) Even if the proceedings were irregular such irregularity did not render the proceedings void or a nullity. Any irregularity, if there was one, could be cured by amendment; and

h) The present proceedings were issued on 29 June 2009.

The rules in the ROI regarding the commencement of proceedings

1038. Order 1, rule 1 of the Consolidated Superior Court Rules provides that civil proceedings in the High Court are instituted by an originating summons.

1039. Order 5 sets out the way in which an originating summons is to be issued. In particular:

a) Every originating summons is to be issued out of the Central Office (Order 5, rule 1);

b) Every originating summons shall bear the date of the day of issue, and shall be sealed with the seal of the High Court (Order 5, rule 8);

c) Every originating summons shall be sealed and marked with the record number by the proper officer "*and shall thereupon be deemed to be issued*" (Order 5 rule 9); and

d) No leave of the Court is required to issue a summons if the summons is not to be served out of the jurisdiction. Further, even if the summons is to be served out of the jurisdiction, in certain circumstances the summons can still be issued without the leave of the Court. Those circumstances are where (i) the claim is one which the Court has power to hear pursuant to the Brussels 1 Regulation, etc, and (ii) no proceedings between the parties concerning the same cause of action are pending between the parties in another member state (Order 5 rule 14).

1040. Borealis contends that the proceedings were not validly commenced in the ROI on 12 November 2007 because the Plenary Summons failed to comply with the requirements of Order 4, Rule 1 which provides:

"I. INDORSEMENT OF CLAIM

1. An indorsement of claim shall be made on every originating summons before it is issued.

[1A. Where an indorsement of claim on an originating summons concerns a claim which by virtue of Regulation No. 44/2001, Regulation No. 2201/2003, the 1968 Convention or the Lugano Convention, the Court has power to hear and determine, the following provisions shall apply:

(1) The originating summons shall be endorsed before it is issued with a statement that the Court has the power under Regulation No. 44/2001, regulation No. 2201/2003, the 1968 Convention or the Lugano Convention to hear and determine the claim and shall specify the particular provision or provisions Regulation No. 44/2001, regulation No. 2201/2003, the 1968 Convention or the Lugano Convention (as the case may be) under which the Court should assume jurisdiction; and

(2) *The originating summons shall be endorsed before it is issued with a statement that no proceedings between the parties concerning the same cause of action are pending between the parties in another Member State of the European Union or in a Contracting State of the Lugano Convention."*

The Plenary Summons did not contain the requisite indorsements. In that respect the proceedings were irregular.

1041. Order 124, Rule 1 of the Rules of the Supreme Court provides:

> *"Non-compliance with these Rules shall not render any proceedings void unless the Court shall so direct, but such proceedings may be set aside either wholly or in part as irregular, or amended, or otherwise dealt with in such a manner and upon such terms as the Court shall think fit".*

1042. I do not regard Borealis' contentions as well founded. When the parties agreed that for limitation purposes these proceedings should be deemed to be commenced at the date when the ROI proceedings were validly commenced they must, as reasonable persons in their position, have intended that the ROI claimants should not be placed in a worse position so far as limitation was concerned than they would have been in if the proceedings in ROI had continued. If the proceedings there were valid for the purpose of determining when an action had been commenced within the limitation period then the date of commencement of those proceedings should be the date applicable, for limitation purposes, for these proceedings.

1043. In using the expression "*validly commenced*" the parties, as it seems to me, were not concerned with whether the proceedings were wholly compliant with the Rules without defect or irregularity but whether they were valid and effective as an action. Proceedings which are void are invalid and without effect. They are as if they had never been. By contrast, proceedings which, by the Rules, are deemed to have been issued and which, although irregular, are not void unless the Court shall so direct, are not, in the absence of any such direction, void, invalid or without effect.

1044. No such direction has ever been made or sought. If such a direction had been sought, it is most unlikely that it would have been made. The overwhelming likelihood is that the Court would have ordered an amendment. In that case, as Mr Collins S.C, opines the "*Summons would for all purposes have been effective to have commenced the proceedings as and from the date of its issue from the Central Office*".

1045. Further there is a plain distinction between whether the proceedings were validly *commenced*, which is determined by Order 1 and Order 5 and was the subject of the parties' agreement, and whether proceedings were properly or regularly *endorsed*, which is determined by Order 4 and was not the subject of such agreement. There is also a distinction between proceedings being "*validly*" commenced and "*properly*" commenced. Insofar as Borealis seeks to equate the two its submissions are ill founded.

1046. Accordingly, in my judgement, this singularly unmeritorious time bar point is not well founded.

Quantum

1047. Having regard to my conclusion that Kingspan fails on liability; and my further conclusion that, if it had succeeded, its damages would be limited to the invoiced value of the Borecene, and, in part, time barred, I do not intend to address what would otherwise have been the quantum of the claim.

Summary

1048. In summary, therefore, I have concluded:

a) that the contracts for the sale and purchase of Borecene were made between Kingspan and Borealis Denmark;

b) that those contracts were subject to the law of Denmark; they were not contracts to which section 27 (2) of the Unfair Contract Terms Act applies; they were international supply contracts; and section 36 of the Danish Contract Law does not invalidate their terms;

c) that the question whether Kingspan has any claim against Borealis Denmark for misrepresentations inducing those contracts is to be determined by the law of Denmark; by which law there is no such claim;

d) that, even if the question is to be determined by the law of England there would be no such claim;

e) that there is, under English law, no separate claim against Borealis UK;

f) that Borealis was not in breach of the terms of the contracts provided for by Danish law;

g) that Kingspan has not established that Borecene, as a result of its intrinsic characteristics or inadequate stabilisation or both, was inherently more susceptible to UV degradation to a degree which would explain the increased failures of Borecene made tanks;

h) that those increased failures are not shown to have been the result of any such susceptibility but are likely to be the result of a combination of factors which include angular designs; failure to optimise processing parameters in the light of the use of a new material with different characteristics; the use on the shop floor of a thickness standard which was less than the design standard; the creation of tanks with unduly low wall thicknesses and unduly high wall thickness variations; a failure to measure thicknesses at corners or to cut up tanks to monitor such thicknesses on a regular basis; and the use of dry blended pigment;

i) that, if Kingspan had been entitled to recover damages, Borealis' liability would have been limited to the invoiced price of the relevant material;

j) that there would have been no applicable Danish law time bar in relation to RM 8402;

k) that there would have been an applicable Danish law time bar in relation to RM 7402 in respect of all deliveries prior to 19 January 2003;

l) that Borealis was not at any material time aware of any non conformity in respect of either RM 8402 or RM 7402; and

m) that there is no applicable Irish time bar in relation to Rom and GSP.