H. Environmental Assessment (EA)

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APPENDICES

H. ENVIRONMENTAL ASSESSMENT

1. **TITLE:** PreMarket Notification for Barex®211-Barex®218 Resin Bottles

2. **DATE:** October 1, 2000

3. **NAME OF PETITIONER:** BP Chemicals Inc.

4. **ADDRESS:** 150 West Warrenville Road
Naperville, Ill, 60563

5. **DESCRIPTION OF PROPOSED ACTION:**

(a) **Requested Approval:**

This PMN requests authorization to use Barex®211-218 Resins. Barex®210 Resins are already approved for food-contact films CFR (177.1480) and for beverage containers (PMN- 000005). An Environmental Assessment was submitted with PMN-000005 which we incorporate by reference. The Barex®211-218 Resins are virtually identical except that the elastomer content is increased from 10 % to a value in the range of 11% to 18%.(The last two numbers of the trade mark identifier refer to the elastomer content). This notification requests no increase in use in the total amount of Barex® Resins used over the amount projected in FCN N0.5. The new copolymer recipes will merely substitute for Barex®210 Resins in some products. In this PMN, for brevity, the copolymer recipes in the range between Barex®211-218 Resins with be referred to as Barex®218. (This follows the convention adopted in the earlier petition and PMN where Barex®208-210 Resins were termed Barex®210).

(b) Need for Action:

The authorization requested in this PMN will permit the manufacture of morc suitable products for the applications approved under CFR (177.1480) and PMN 000005. The use of more elastomer is desirable in certain applications where increased impact resistence is important, e.g. larger beverage containers.

(c) Locations of Use:

The nitrile rubber modified acrylonitrile methyl acrylate copolymer, trade marked as Barex®218 will be incorporated into containers at production plants located throughout the United States. Containers and films fabricated from the copolymers are expected to be used by consumers primarily in the home but also in other food distribution sites, e.g., stores, restaurants, at sports events, and other places where consumers ingest beverages or buy film-packaged foods. The use and distribution of Barex®218 will essentially be identical to the currently approved use and distribution of Barex®210.

(d) Locations of Disposal:

Disposal of food-packaging materials that are subject to the proposed action is expected to occur nationwide with the materials ultimately being deposited in municipal solid waste landfills or incinerated.

6. IDENTIFICATION OF CHEMICAL SUBSTANCES THAT ARE SUBJECT OF THE PROPOSED ACTION:

(This section is identical to the corresponding section in PMN 000005).

(a) Complete Nomenclature:

The principle constituent of Barex®218 Resin is (acrylonitrile/methyl acrylate)-g-(butadiene/acrylonitrile) copolymer.

(b) Chemical Abstracts Service (CAS):

CAS Number: 27012-62-0

(c) Molecular Weight:

The basic resin polymer is a complex mixture of long polymer chains, some linear, some cross-linked and some branched. Most of the material is heavily grafted and cross-linked and has a weight average molecular weight greater than 1,000,000 atomic units. The mean chain size of ungrafted chains is 100,000 atomic units.

(d) Molecular Formula:

The approximate empirical formula is $C_8H_{10.3}ON_{1.7}$. Because the exact empirical formula is subject to conditions of manufacture including temperature and pressure, the empirical formula given is a best estimate.

Structural (Graphic) Formula:

The basic resin is composed of polymerized units of acrylonitrile, methyl acrylate and 1-3-butadiene containing the following units in many different combinations with one another: -(CH2CNCH-)-, -(CH2CHCO2CH3-)-, -(CH2CH=CHCH2-)- and –(CH2CH2-CH=CH)-

(e) Physical Description:

Barex®218 bottles typical of those proposed for juices, drinks and teas are depicted in Brochure No. BX-101. Barex®218 bottles will be fabricated from extrusion grade resin. Descriptive brochures and sheet samples are attached to this EA, (Attachment 1).

7. INTRODUCTION OF SUBSTANCES INTO THE ENVIRONMENT:

(a) Manufacture:

There are no extraordinary circumstances involved in the manufacture of Barex®218 Resin. The manufacturing process, except for the use of more elastomer in the recipe, is identical to that for Barex®210 Resin. The manufacturing process for Barex®218 Resin conforms to all general and specific emission requirements (including occupational) promulgated by Federal, State or local environmental agencies. There is no additional production of Resin contemplated in the proposed petition and the increase in the amount of Barex®218 Resins produced will be offset by the decrease in the amount of Barex®210 Resins.

(b) Use:

Little or no introduction into the environment of the copolymer subject to this section will result from its use because the copolymer is almost completely incorporated into food-packaging materials and essentially all of the copolymer is expected to remain with food packaging throughout the use of the polymer.

(c) Disposal:

Based on migration studies, which were performed to demonstrate the safety of the copolymer subject to this action and reported elsewhere in this notification, only very low levels of substances are expected to leach from articles fabricated with the copolymer after disposal to landfills. The copolymer subject to this notification is composed of carbon, hydrogen, oxygen, and nitrogen. Adding the copolymer to waste that is burnt will not alter significantly the emission from municipal waste incinerators. The market volume of the copolymer is a very small fraction of the municipal solid waste generated and disposed of in any single combustion site or in the United States as a whole. See **Table H.1**.

8. FATE OF EMITTED SUBSTANCES IN THE ENVIRONMENT:

No information need be provided of the fate of substances released into the environment as a result of use and disposal of the subject copolymer, because as discussed under item 7, only small quantities, if any, of substances will be introduced into the environment.

9. ENVIRONMENTAL EFFECTS OF RELEASED SUBSTANCES:

No information need be provided on the environmental effects of substances released into the environment as a result of use and disposal of the subject copolymer, because as discussed under Item 7, only small quantities, if any, of substances will be introduced into the environment. Therefore, the use and disposal of the copolymer is not expected to threaten a violation of applicable laws and regulations, e.g., the environmental Protection Agency's regulations in 40 CFR part 60 that pertain to municipal solid waste combustors and part 258 that pertain to landfills.

10. USE OF RESOURCES AND ENERGY:

(a) <u>Basic Information:</u>

(1) **<u>Market volume:</u>** The anticipated maximum production volume for all the uses of Barex® resins is approximately . Current production is approximately **(Table H.1)**. Of this ,

approximately is exported, giving of Barex® resin used domestically. Of this virtually none, at this time, is used for beverage containers in the United States. The bottles listed in **Table H.1** are for use abroad or for industrial use, not for food-contact use.

We anticipate no more than of Barex® resin for eventual beverage use in the United States. (A maximum market volume for beverage use was indicated in the recently authorized PMN 000005 and no increase in use is requested in this PMN).

Furthermore, no increase in use is requested for films or sheets since Barex®218 resins will substitute for already approved uses of Barex® 210 resins. The anticipated distribution of different Barex® resins up to the production capacity of 40 million pounds is given in **(Table H.2)**.

As discussed in PMN 000005 the maximum production volume is inherently limited by production capacity as well as market size (Ref. PMN 000005). The proposed market for Barex®218 containers is also limited by the restricted nature of the proposed food applications, i.e., – teas and fruit and vegetable juices and drinks. According to U.S.

Department of Agriculture (USDA) data, annual per capita consumption is 8.6 gallons for juices, 5.7 gallons for drinks, and 7.0 gallons for teas. According to U.S. Census estimates as of July 1, 1995, the population of the United States was 262,755,000 individuals. If we combine the per capita figures for juices and drinks, and multiply by the approximate U.S. population, we obtain a total market size of 3.76 billion gallons per year. Performing the same calculation for teas we obtain a total market size of 1.84 billion gallons per year.

A realistic estimate for bottle size and weight would be an average size of one liter and an average weight of 40.3 grams per bottle. With Barex®218 Resin production of 10 million pounds, bottle production could be million bottles, if we make the extremely conservative assumption that all added Barex®218 Resin production will go into the United States juice and drink market. If these bottles held one liter each, million bottles would contain . Dividing by the annual market for juices, drinks and teas of 5.6 billion gallons would give a market share of only percent. (**The estimate of of Barex® Resin was made in the earlier PMN 000005. We now have more accurate information and the current estimate is only , but we will use for consistency**).

The market share available to Barex®218 Resins is considerably smaller for the following reasons. There are physical limitations on the use of Barex®218 Resins in these markets. Due to the inherent thermal properties of the resin (low Tg), bottles blown from Barex®218 Resins cannot be hot-filled. Half of containers for juices, drinks, and teas bottled in the United States are hot-filled. The other half of the market is aseptically filled or cold filled. Consumer application patterns also limit the market potential for Barex®218 Resin bottles. In the juice market, based on data obtained from MRCA, about 27 percent of the consumption is from frozen concentrate. If the product is frozen, the outstanding oxygen barrier provided by Barex®218 Resins is not required. In the drinks market, 53 percent of the consumption is home prepared from dry powder which would also eliminate the requirement for Barex®210 Resins. In the tea market, only 2 percent of the total consumption is canned or bottled, the majority being home prepared from hot water and tea bags. (Attachment 3 of the EA for PMN 00005,: MRCA's Report of Consumption Patterns.) Finally, there are economic limitations to the market potential for Barex®218 Resin bottles. juices, drinks, and teas are currently packaged in a variety of materials including glass, paperboard, aluminum, and plastics. The choice of material is based on a variety of factors including cost. Barex®218 Resins are high-cost materials and they would be selected only for premium quality applications in which package transparency and a superior oxygen barrier is required. Of the 50 percent of the juice and drink market which is aseptically or cold filled, 85 percent is packaged in paperboard "bricks" or "gable top" paper cartons. If marketers of these products do not value package transparency, they will not select the more expensive Barex®218 Resins for their products. Even where transparency is desired, other plastics provide a less expensive package, unless a superior oxygen barrier is needed. Consequently, only premium quality niche products make sense for Barex®218 Resins. These premium quality market niches are small by industry standards. Realistically, we anticipate no more than per year of demand for Barex®218 Resins due to our entry into the United States juice, drink, and tea markets.

(2) **Product Type Distribution:** **Table H 1** lists the current and maximum anticipated market volume for Barex® resins. The distribution between bottles and sheet products is presented. Current market volume Barex® resins is approximately 28 million pounds of which approximately 20 million pounds is used and discarded domestically. The maximum projected market volume for Barex® resins is shown in **Table H.2**. As indicated in this PMN, **Section B. Use,** we anticipate the domestic market volume can increase by 4 million pounds. (In the previous PMN 000005 we used 10 million pounds for this estimate, we retain the 10 million pounds in this EA for consistency, but we believe 4 million is much more accurate.) Additional information on food applications packaging materials of Barex® resins is given in the EA for Barex® 210 resins, PMN 000005.

Table H.1

Current Market Volume of Barex® Resins and Product Types

Barex Resin	Million (M) Pounds	Product Type		Resin %
		Bottles	Sheet	
Barex® 210		4.5	1	27.5
Barex® 214		0	13.5	67.5
Barex® 218		1		5.0
Total = - [exported + unused capacity] = used domestically.				

Table H.2 Maximum Projected Market Volume of Product Types				
Barex Resin	**Million (M) Pounds**	**Product Type** **Bottles**	 **Sheet**	**Specific Resin % of Total**
Barex® 210		6.5	0	27
Barex® 214		1.0	12.5	56
Barex® 218		4	0	17
Total =	**-**	**exported =**	**used domestically**	

(3) **Competitive food-packaging materials** The proposed use of Barex®218 resin beverage bottles including 1/2 liter, 1 liter, 2 liter, 1 gal and 2 gal sizes is anticipated to compete with the current packaging types used for teas and fruit and vegetable juices or drinks. As discussed in PMN 00005, the principal competitors for the smaller sized bottles will be glass and other plastic containers, primarily PET. We anticipate that the major competitor for the 2 liter and larger sizes will be primarily other plastic containers such at PET. Glass is not widely used for 2 liter or larger containers for teas and fruit and vegetable juices or drinks. The proposed used of Barex®218 resin films and sheets will be identical to those approved under CFR 177.1480; we anticipate some substitution of the current Barex®210 resin in favor of Barex®218 resin for these uses.

(4) **Distribution of Bottled Sizes** PMN 000005 proposed the use of 1 and 1/2 liter, beverage bottles for Barex®210 Resin and the waste disposal issues and energy utilization issues were discussed in for those bottle sizes. Barex®218 Resins will also be used to make larger bottle sizes including 2 liter and 1 and 2 gallon sizes. As indicated in **Table H.2,** a maximum of 4M lbs of the Barex®218 Resin will be for bottles, 75 % 1 liter juice bottles and 25% in larger bottles up to 2 gallons. We anticipate an even split between 2 liter, 1 quart, 1 gallon and 2 gallon containers.

(5) **Disposal Patterns:** Beverage containers made from the subject copolymer will eventually become part of the municipal waste stream (MSW) and are either buried in

land fills or incinerated in municipal or other waste disposal plants. This conclusion is based on evidence that little if any Barex®218 bottles are likely to be recycled. The EPA report, "Characterization of Municipal Solid Waste in the United States: 1997 Update" (EPA CMSW, 1998), contains recent information on disposal patterns of different waste types. Table 7, page 38-39 of this report shows that only 0.96 percent of the category of "other resins" are recycled. This is the category that is assigned to nitrile rubber modified acrylonitrile methyl acrylate copolymer (trade marked as Barex®218 containers).

The EPA data show that when there is no recycling of a plastic material, 76 percent is disposed of in landfills and 24 percent is incinerated (EPA CMSW, 1998, page 2). This amounts to a maximum land disposal of 3,800 tons of Barex®218 bottles. The landfill required for of Barex®218 is cu. yd/year (assuming pounds or tons of Barex®218). This assumes a bulk density of 355 lbs/cu.yd. for plastic containers. Approximately 0.24 x tons or tons of Barex®210 will be incinerated. Generation and recovery data for glass, plastic and Barex®210 containers are given in **Table H 3.** The glass and MSW data are taken from Tables 5, 7 and ES-1 in EPA's 1998 report:

"Characterization of Municipal Solid Waste in the United States: 1997 Update" U.S. EPA Municipal and Industrial Solid Waste Division, Office of Solid waste Report No. EPA530-R-98-007.

Conclusions Regarding Landfill: The reduction in bottle volumes caused by compaction in landfills will be proportional to the anticipated bulk densities for glass and Barex®218. From Table B-8 in the EPA Report mentioned above, we have taken the appropriate bulk densities for glass and Barex®218 as 2,800 and 355 lbs/cu.yd., respectively. This is a ratio of 1 to 7.9. Thus there will be no impact on landfill from bottles of different volumes; the bulk densities of all Barex bottles will be the same. We therefore incorporate by reference the material submitted with PMN 000005 in support of Barex®210, since as far as disposal is concerned the substitution of Barex®218 for Barex®210 resins, and the inclusion of large sized bottles in the waste stream will not alter the conclusions made formerly made and accepted.

Because of the vast use of both plastic containers and glass bottles for other food uses and for non-food uses the impact of Barex®218 bottles on the waste stream will be negligible in comparison. (Attachment 4: Facts and figures of the Plastics Industry, 1996, PMN 00005). This overriding fact, summarized in **Table H 3**, should be borne in mind in evaluating the information below.

TABLE H.3

Approximate Generation and Discard of MSW and Glass, Plastic, and Barex®218 Containers Based on US EPA 1997 Data

Product Category	Generation (1000 tons)	Recovery		Discard	
		(1000) tons	percent	(1000) tons	percent
Total MSW	209,700	57,300	27.3	153,400	72.7
Glass Products	12,400	3,170	25.7	9,180	74.3
Glass Containers	11,000	3,170	28.7	7,870	71.3
Plastic Products	19,760	1,060	5.4	18,700	94.4
Plastic Containers	2,630	670	25.5	1,960	74.5
Barex®210 Containers*		Neg.	0.0		100

***Based on estimated Barex®218 production capacity of pounds.**

(b) Potential for Impacts on Solid Waste Management Strategies and Energy Use

(A) *Impacts on recycling:*

In PMN 000005 we explained why Barex®210 Resin would not impact the waste stream of recycled materials. Summarizing that information:

(1) We showed that containers made from Barex®210 Resin would not be recycled to any significant extent: Barex®210 Resins are classified in the same recycling category–recycle code 7. There is currently very limited recycling of plastics classified in recycle code 7. This is also true for Barex®218 Resins.

(2) We showed that containers from Barex®210 Resin would not interfere with the recycling of other transparent plastic containers like PET. The physical characteristics of Barex®210 bottles are sufficiently distinctive and either singly or combined allow easy recognition and separation of Barex®210 bottles from the waste stream. This is also true for Barex®218 Resins.

The increase in elastomer content has no significant impact on product color, haze, IR-spectra and density; the physical characteristics useful in distinguishing Barex®resins from other plastics in the recycling stream. (See **Section A. Identity** of this PMN).

(3) Barex®210 Resin is already on the market in the form of extruded sheets for food packaging. There is no significant recycling of plastic sheet and film products made from Barex®210. This is also true for Barex®218 Resins.
For additional details we refer the reader to the EA in PMN 000005.

(B) Impacts on landfill:

Because the proposed food additive will have a relatively small market volume it cannot add significantly to the amount of landfill space required. As shown in **Table H3**. Barex®218 bottles will be at most 5/18,700 = 0.027% of the plastic waste stream and only 5/153,430 = 0.003 % of the total MSW waste stream. This overall impact should be kept in mind as specific landfill tradeoffs for competitive containers are considered in turn below.

The impact on landfill of Barex®218 relative to glass depends upon the relative amounts of the two materials required to make a bottle of a given size. According to data provided by FDA, a liter glass bottle made from the new lighter-weight glass can be expected to weigh approximately 3 times more than a Barex®210 bottle. (V. R. Sellers, Comparative Energy and Environmental Impacts for Soft Drink Delivery Systems, National Association for Plastic container Recycling, Franklin Associates, Prairie Village, KS, March 1989, Tables 3-3 and 3-4).

However according to other FDA data, a typical polymeric bottle (e.g PET), weighs just one eighth as much as a comparable glass bottle. Our own survey of currently used iced tea, and juice containers found an 8-10 fold difference in weight between glass and polymeric containers of a liter and ½ liter size. Accordingly, in the calculations below we use factors of both 3 and 8 to gauge the impact on landfill. We use these same figures for the larger sized bottles.

The current PMN requests one quart, 2 liter, one gallon and 2 gal containers in addition to the one liter bottles authorized under PMN 000005. This change to larger sizes will tend overall to lesson the competition with glass containers and increase the competition with plastic containers since glass beverage containers larger than 2 liters are relatively rare. However, this effect will be minor as 75% of the bottles are still expected to be 1 liter or less. This change is well within the accuracy of the estimates given for landfill in PMN 00005. We therefore incorporate the following section from PMN 000005.

***(i) Barex®210 Resin bottles versus acrylonitrile/styrene*:**
As discussed under Section 10(a)(3) we believe that Barex®210 bottles will not compete with acrylonitrile/styrene copolymers for the proposed food container market. While acrylonitrile/styrene are approved for use in beverage containers, we are not aware of any present market applications in our requested food product area. Consumers and food packaging companies prefer glass bottles or plastic containers with other properties than those possessed by acrylonitrile/styrene copolymers.

(ii) Barex®210 Resin bottles versus Glass:
The total weight of competitive glass used would be approximately 3 x 5,000 tons) or 15,000 tons. We expect that 26 percent of glass competitive with Barex®218 bottles or 15,000 tons x 0.26 = 3,900 tons will be recycled based on the same source of information. Therefore 0.74 x 15,000 tons or 11,100 tons of glass will be discarded. If on average 76 percent of this is discarded in landfill, as indicated by the EPA data, the total glass waste currently added to the waste stream is 0.76 x 11,100 tons or 8,440 tons. If Barex®218 bottles replaced this use, 8,440 tons of glass or 6,025 cu.yd. of solid waste would be removed from the waste stream. Similarly 0.24 x 11,100 tons of discarded glass or 2,660 tons will be incinerated. Due the extra compaction of fused glass (bulk density = 4,400 lbs/cu.yd, (EPA, CMSW 1998) this will give rise to 1,210 cu. yd. of landfill. The total quantity of landfill volume required for disposal of the Barex®218 bottle market equivalent of competitive glass packaging = 6,025 + 1,210 = 7,235 cu.yd. These data are Tabulated in Table 2, Scenario 1A and 1B. We use the 8-fold density ratio for glass/plastic in the B scenarios. This assumption makes a large difference, approximately 7-fold to the net landfill difference.

***(iii) Barex®210 Resin bottles versus other plastic containers*:**

We believe that Barex®218 bottles will compete significantly with other partially recyclable plastic containers. According to EPA data, 14.8 percent of plastic containers and packaging (exclusive of soft drink bottles and milk containers) is presently recycled (Table 7, EPA, CMSW, 1998, page 40). The remainder is disposed of either by incineration (24%) or by landfill (76%). Barex®218 is not presently recycled and it is not anticipated to be recycled appreciably in the future. In most other respects: methods of production, incineration, bottle size, compaction in the landfill, etc., Barex®218 bottles and other plastic containers are approximately the same. Barex®218 bottles differ from competitive plastic containers in only two respects: density and recyclability. The density of PET is 1.35 vs 1.15 for Barex®218. A consequently greater mass of competitive plastic (5,870 tons vs 5,000 tons) must be used to equal the bottling capacity of Barex®218. Thus the potential environmental gain from competitive plastics is offset by the greater mass of plastic used. This is shown in **Table H 4** under Scenario 2. The discarded amount of Barex®218 is of course trivial compared to the total plastic discard of 1,960,000 tons. **(See Table H 3).**

(iv) Barex®218 and 50/50 glass/plastic replacement:

The last six rows in **Table H 4** (Scenario 3A and 3B) give the results of the landfill calculations if it is assumed that half the market share anticipated for Barex®218 bottles comes from glass containers and half from other plastic containers. It is clear that the more Barex®218 Resin replaces other plastic, with which it shares more similarity, the lessor the impact on landfill becomes. Using the 8-fold density ratio, a 50/50 glass/plastic replacement produces very little net change in landfill requirements - only 1,006 cu.yd. But regardless of the replacement scenarios, the impact on the waste stream is very minor because the market volume for Barex®218 bottles is small in commodity terms.

Sample Calculations:

Since only 74 percent of glass remains unrecycled and 24 percent 0f this is incinerated and 76 percent goes into landfill we have:

↗incinerated = 2,660 tons

(0.24)

Glass discard = 5,000 tons x 3 x 0.74 = 11,100 tons ----

(0.76)

↘landfill = 8,400 tons

Since there is no recycling of Barex®218, we have:

↗incinerated =1,200 tons

(0.24)

Barex discard = 5,000 tons --------

(0.76)

↘landfill = 3,800 tons

Table H 4

Estimated Landfill Required For Barex®218 Bottles and Competitive Containers

Mat.	Generated	Recycled	Material Discarded		Landfill (cu. Yd.)		Landfill Totals
	(Tons)	(Tons)	Incinerated (Tons)	Landfill (Tons)	Recovered From Incin	Directly Added	
Scenario (1A): 100% Replacement of Glass Containers (x3)							
G(x3)	15,000	3,900	2,660	8,440	1,210	6,025	(-) 7,230
B		0			0	21,400	(+) 21,400
				Net Change in landfill volume			(+) 14,400
Scenario (1B): 100% Replacement of Glass Containers (x8)							
G(x8)	40,000	10,400	7,104	22,496	3,229	16,068	(-) 19,300
B		0			0	21,400	(+) 21,400
				Net Change in landfill volume			(+) 2,100
Scenario (2): 100% Replacement of Plastic Containers							
P	5,870	869	1,197	3,804	0	21,370	(-) 21,370
B		0			0	21,400	(+) 21,400
				Net Change in landfill volume			Neg
Scenario (3A) 50/50 Glass/Plastic Container Replacement (x 3)							
G(x3)	7,500	1,950	1,330	4,220	605	3,012	(-) 3,620
P	2,935	435	598	1,902	0	10,685	(-) 10,685
B		0			0	21,400	(+) 21,400
				Net Change in landfill volume			(+) 7,095
Scenario (3B) 50/50 Glass/Plastic Container Replacement (x 8)							
G(x8)	20,000	5,200	3,552	11,248	1,615	8,034	(-) 9,649
P	2,935	435	598	1,902	0	10,685	(-) 10,685
B		0			0	21,400	(+) 21,400
				Net Change in landfill volume			(+) 1,066

G = Glass, P = Plastic and B =Barex®218

Density of fused glass = 4,400 lbs/cu.yd.=2.2 tons./cu.yd.

Bulk density of compacted glass = 2,800 lbs./cu.yd. =1.4 tons.cu.yd.

Bulk density of compacted plastic or Barex®218 bottles = lbs./cu.yd. = tons./cu.yd.

Density of plastic (PET) = 1.35 g/cc; density of Barex®218 Resin = 1.15 g./cc.

(b) Impacts on Energy Use:

(A) *Approach to the calculations*:

As above, we assume complete market penetration by 10 millions pounds of Barex®218 resin and its 29.8 million-gallon capacity. (See **Section 10(a)(1) Market volume**.)
Prior to the entry of Barex®218 bottles, we assume this volume of product is packed equally in unrefillable glass containers and in other transparent plastic containers, e.g., PET , HDPE and PP.

Barex®218 bottles are not expected to be recycled and a significant fraction (estimated at 50 percent in the energy calculations) will likely replace glass, which is currently recycled. In these circumstances the energy to produce, transport, use and dispose of the subject copolymer and glass may differ. Because a PET bottle weighs only one-eighth as much as a comparable glass container and Barex®218 Resin is 1.35/1.15 times lighter than PET, we multiply the expected market volume for Barex®210 bottles by 8 x 1.35/1.15 = 9.39 to obtain the market volume of the glass that will be replaced.

The means of container production, handling and disposal of Barex®218 bottles and other transparent plastic bottles are similar. Therefore the energy profile for PET bottles (from the 1989 Franklin Associates Report) will be used as a surrogate for Barex®218 bottles. Barex®218 Resin bottles require less energy for manufacture than many other containers, from acquisition of the raw material, manufacture, through ultimate disposal of the raw material. Because of its greater strength, less raw material is required for the Barex®218 Resin bottles than for competitive plastic containers. A Barex®218 one liter bottle weighs 40.3 grams compared to 46.8 grams for a one liter PET bottle. A corresponding ratio exists for larger bottle sizes.

Additionally, the energy required to dispose of Barex®218 bottle will be slightly different from other plastics. This difference arises from recycling and occurs only for the fraction of the plastic containers that are recycled. According to Table 7 in the EPA report referred to above, (CMSW, 1998), about 14.8 percent of plastic containers in this product category is recycled. This recycling would not occur for Barex®218 containers. The energy costs of this effect would be small, given the very small impact of the Barex®218 bottle market on the total plastic waste stream. **(See Table H 3).**

The net result of the Barex®218 bottle entry (assuming complete market penetration and 50/50 replacement of glass and other plastic containers) would be to substitute a 29.8 million gallon-capacity of Barex®218 containers equally for other plastic and glass containers. We would then have added a 29.8 million-gallon Barex®218 bottle capacity and lost 14.9 million gallons formerly packed in other plastic containers and 14.9 million gallons formerly packed in glass containers. This would add 10 million pounds of Barex®218 bottles and eliminate $10^7/2 \times 1.35/1.15 = 5.87$ million pound of other plastic containers and $10^7/2 \times 1.35/1.15 \times 8 = 47.0$ million pounds of glass containers. We use the "cradle–to-grave" energy values that are reported in the 1989 Franklin Associates NAPCOR Final Report for both PET and non-refillable glass containers. The pertinent Tables of the report are attached to the EA in PMN 000005. (Attachment 6). Since the anticipated market calls for 1-liter and ½ liter containers the calculations for both Barex®218 bottles and its competitors are for bottles of this size. **Table H 5** reproduces the pertinent data from the NAPCOR Final Report. For the larger sizes (2 liter and 3 liter we used the 1990 data from a more recent NAPCOR Tables supplied by FDA.

(B) ***Basic calculations***

To compare the energy profiles for PET, Barex®218, and glass containers we normalize the energy analysis on the basis of energy consumed per amount of food product container. Following the NAPCOR Report we use million BTU's per 1000 gallons. The most recent data refer to projections for 1995. The Tables in Attachment 6, PMN 00005, give the energy consumed throughout the life cycle of the container, including, production, recycling, secondary packaging, filling and distribution and solid waste disposal.

TABLE H 5 1995 Projected Cradle-to-Grave Energy Requirements for Glass and Polymeric Bottle Systems in Million BTU (MBTU) per 1000 Gallons. Adapted from Franklin Associates 1989.			
Material	**Size**	**Virgin Container**	**Recycled Container**
	3 liter	18.57	13.10
	2 liter	18.97	13.22
PET	1 liter	22.37	14.95
	½ liter		
Non-refillable	1 liter	26.05	23.89
Glass	½ liter	26.89	24.94
	3 Liter	18.57	N/A
	2 Liter	18.97	N/A
Barex®218	1 liter	22.37	N/A
	½ liter	27.85	N/A

The energy required for a particular beverage container in MBTU/year is given by:

$E_{PRODUCT} = E_{AVG/CONT} \times CW \times MV \times k$, where, (equation 1)

$E_{AVG/CONT} = (E_{RECYCLED} \times p) + (E_{VIRGIN} \times [1-p])$ (equation 2)

Where: $E_{RECYCLED}$ = sum of energy needed for containers made from the recycled material.

E_{VIRGIN} = sum of energy needed for new (virgin) containers.

p = the fraction of the market volume expected to come from recycled materials.

CW = container capacity per unit weight. (liters /gram)

MV = market volume of product. (lbs/year)

k = conversion constant = 0.115 (gal-gm/liter-lb) or = 0.00354 (gal-gm/fl.oz-lb).

Applying equation (2) to Barex®218, PET and glass 1 and ½ liter containers in turn and using the NAPCOR data reproduced in **Table H 5**, the total energy requirements for the various container systems are derived in **Table H 6.**

Table H 5 and **Table H 6** presented in this PMN are identical tothe corresponding ones in PMN 00005 with the single addition of the data for larger bottle sizes.

TABLE H 6

Total Energy Requirements for Various Containers Using NAPCOR Energy Values and Recycling Rates (In MBTU/1000 Gallons)

PET	
3 Liter	**2 Liter**
E_{AVG} = (13.10 x 0.148) + (18.57 x 0.852) = 1.94 + 15.82 = 17.76 MBTU/1000 gal	E_{AVG} = (13.22 x 0.148) + (18.97 x 0.852) = 1.96+ 16.16 = 18.12 MBTU/1000 gal
1 Liter	**1/2 Liter**
E_{AVG} = (14.95 x 0.148) + (22.37 x 0.852) = 2.21 + 19.06 = 21.27 MBTU/1000 gal	E_{AVG} = (18.62 x 0.148) + (27.85 x 0.852) = 2.75 + 23 73 = 26.48 MBTU/1000 gal
GLASS	
1 Liter	**1/2 Liter**
E_{AVG} = (23.89 x 0 26) + (26.05 x 0.74) = 6.21 +19.28 = 25.49 MBTU/1000 gal	E_{AVG} = (24.94 x 0.26) + (26.98 x 0.74) = 6.48 +19.97 = 26.45 MBTU/1000 gal
Barex®218	
2 Liter	**3 Liter**
E_{AVG} = 18.97 MBTU/1000 gal	E_{AVG} = 18.57 MBTU/1000 gal
1 Liter	**1/2 Liter**
E_{AVG} = 22.37 MBTU/1000 gal	E_{AVG} = 27.85 MBTU/1000 gal
PET recycling @ 14.8 % ; Glass recycling @ 26% ; Barex®218 recycling @ 0%	

It is seen that the energy efficiency of both glass and plastic containers decreases, as the containers become smaller.

Specific Comparisons:

(i) Barex®218 Resin bottles versus acrylonitrile/styrene

A comparative analysis of the impact on energy between the subject copolymer and the competitive acrylonitrile/styrene is not needed because (1) No competition between Barex®218 bottles and acrylonitrile/styrene containers is anticipated.

(ii) Barex®218 Resin bottles versus glass or other plastics

Applying equation (1) with appropriate values of CW, MV and material densities yields the values tabulated in **Table H 7**.The figures in **Table H 7** are used along with the approximations and assumptions regarding market volume and the 50/50 glass-plastic competitive replacement to compute the actual energy expenditures. A sample calculation for 1-liter bottles is presented below. Introduction of Barex®218 (1 liter) containers would result in an energy credit of 44,721 MBTU/yr. versus the replaced 1-liter glass containers and an energy deficit of 12,200 MBTU/yr versus the replaced 1-liter PET or similar recyclable containers. The net effect is an energy credit of 32,521 MBTU/yr. from the entry of Barex®218 bottles and equal replacement of glass and plastic containers. The energy saving comes from the combined effect of replacement of glass bottles, which are very energy inefficient versus Barex®218 bottles, and the relatively minor energy addition due to the loss of recycling of PET and similar plastics.

Net = 50%Barex®218 – PET + 50%Barex®218 – GLASS

= 319,000 – 306,800 + 319,000 – 363,721

= (+) 12,200 + (-) 44,721

= (-) 32,521 MBTU/yr

Table H 7

Final Energy Comparisons For Barex®210 Bottles, Glass and Other Plastic Containers Using Anticipated Market Volume of Ten Million Pounds of Barex®218 Resin

1 Liter	½ Liter
E_{PET} = 21.27 x 1/46.8 x 0.115 x 5.87 x 10^6 = 0.05227 x 5.87 x 10^6 = 306,800 MBTU/yr.	E_{PET} = 26.48 x 0.5/27.5 x 0.115 x 5.87 x 10^6 = 0.05537 x 5 87 x 10^6 = 325,000 MBTU/yr.
2 Liter	**3 Liter**
E_{PET} = 18.12 x 1/46.8 x 0.115 x 5.87 x 10^6 = 0.04453 x 5.87 x 10^6 =261,360 MBTU/yr	E_{PET} = 17.76 x 1/46.8 x 0.115 x 5.87 x 10^6 = 0.04364 x 5.87 x 10^6 = 270,660 MBTU/yr
1 Liter	**½ Liter**
E_{GLASS} =25.49 x 1/(40.3 x 9 39) x 0.115 x 47 x 10^6 = 0.00774 x 47 x 10^6 = 363,721 MBTU/yr.	E_{GLASS} = 26 45 x 1/(40.3 x 9 39) x 0.115 x 47 x 10^6 = 0.00803 x 47 x 10^6 = 377,420 MBTU/yr.
1 Liter	**1/2 Liter**
E_{BAREX} = 22.37 x 1/40.3 x 0.115 x 5.0 x 10^6 = 0.0638 x 5.0 x 10^6 = 319,000 MBTU/yr	E_{BAREX} = 27 85 x 0 5/(27.5x 0 852) x 0.115 x 5.0 x 10^6 = 0.06835 x 5.0 x 10^6 = 341,700 MBTU/yr
2 Liter	**3 Liter**
.E_{BAREX} = 18.97 x 1/40.3 x 0.115 x 5.0 x 10^6 = 0.05413 x 5.0 x 10^6 = 270,660 MBTU/yr	.E_{BAREX} = 18.57 x 1/40.3 x 0.115 x 5.0 x 10^6 = 005299 x 5.0 x 10^6 = 264,910 MBTU/yr

Table H 8 shows the energy requirements for the three scenarios: where Barex®218 bottles compete: 100% with similar sized glass containers, 100% with similar sized PET containers or 50/50 with similar sized glass and PET containers. The energy values with the positive signs indicate added energy burdens; those with the negative signs indicate energy that would no longer be needed. **Table H 8** shows that the energy gain using ½ liter bottles is only about half as much as that for 1- Liter bottles. A net energy decrement is predicted when Barex®218 totally replaces other plastic containers in this market niche. This is due to the efficiency gained when a portion of other plastic containers are recycled. This 100 % replacement scenario will not occur, but it were to occur, it still would entail a very small relative energy cost.

For bottle sizes of 2 liters or more, plastic containers provide the sole competition as glass is infrequently used for these larger sizes. The larger the size of bottle the less the relative energy cost of Barex®218 bottles versus PET. As **Table H 8** indicates, the net added energy cost entailed with the 100% replacement of PET with Barex®218 decreases substantially as the bottle size increases. Thus although we have no data from which to estimate an energy comparison for 1- and 2- gallon bottles and their replacements, we conclude that, while there may be a net energy cost from replacing large PET bottles with these large Barex®218 bottles, we expect this increase to be small, i.e., smaller than the energy increase calculated in Table H8 for the three liter bottle replacement. The use of larger bottles is thus more environmentally friendly.

Table H 8

Comparison of Energy Requirements in MBTU/yr. For Barex®210 And Competitive Containers

Container		100% Glass Replacement	100% PET Replacement	50%/50% Replacement
PET	1 liter	N/A	(-) 613,600	(-) 306,800
	½ liter		(-) 650,000	(-) 325,000
GLASS	1 liter	(-) 727,442	N/A	(-) 363,721
	½ liter	(-) 754,840		(-)377,420
BAREX	1 liter	(+) 638,000	(+) 638,000	(+) 638,000
	½ liter	(+) 683,400	(+) 683,400	(+) 683,400
NET	3 liter	N/A	(+) 8,790	N/A
	2 liter	N/A	(+) 9,360	N/A
	1 liter	(-) 89,442	(+) 24,400	(-) 32,521
	½ liter	(-)71,440	(+) 33,400	(-)19,020

11. MITIGATING MEASURES:

No significantly adverse impacts have been identified for the proposed action, and therefore no mitigation measures are necessary.

12. ALTERNATIVES TO THE PROPOSED ACTION:

No significantly adverse impacts have been identified for the proposed action.

13. PREPARED BY:

Robert J. Scheuplein, Ph.D
Keller & Heckman LLP

Robert C. Sentman, Ph.D.
Manager, Barex Technology
BP Chemicals Inc.

14. CERTIFICATION:

The undersigned officials certify that the information presented is true, accurate, and complete to the best of the knowledge of Keller and Heckman LLP, and the BP Chemical Company.

Signature of the responsible official(s) responsible for preparation of the environmental assessment:

Robert J. Scheuplein Keller & Heckman LLP	Nancy Kutz BP Chemicals Inc.
Dec 6, 2000 DATE	Dec 6, 2000 DATE

EN

Appendix V

APPENDIX V

[redacted]

Table WS-7

CURRENT AND PROJECTED ENERGY REQUIREMENTS FOR THE COMPONENTS OF THE 2-LITER PET BOTTLE SYSTEM
(Million Btu per 1,000 gallons)

Component	1987	1990	1995
PET Bottle System			
Virgin Raw Materials	12.64	11.90	10.74
Recycled Raw Materials	6.71	6.34	5.75
Secondary Packaging	2.71	2.44	2.08
Filling/Distribution	4 53	4.43	4.10
Solid Waste Disposal			
Virgin Bottle	0.20	0.20	0.20
Recycled Bottle	0.01	0.01	0.01
Total			
Virgin Bottle	20.08	18.97	17.12
Recycled Bottle	13.96	13.22	11.94

Source: Franklin Associates, Ltd.

Table WS-8

CURRENT AND PROJECTED ENERGY REQUIREMENTS FOR THE COMPONENTS OF THE 3-LITER PET BOTTLE SYSTEM
(Million Btu per 1,000 gallons)

Component	1987	1990	1995
PET Bottle System			
Virgin Raw Materials	12.07	11.32	10.42
Recycled Raw Materials	6.41	6.03	5.58
Secondary Packaging	2.97	2.68	2.25
Filling/Distribution	4.49	4.38	4.05
Solid Waste Disposal			
Virgin Bottle	0.19	0.19	0.19
Recycled Bottle	0.01	0.01	0.01
Total			
Virgin Bottle	19.72	18.57	16.91
Recycled Bottle	13.88	13.10	11.89

Source: Franklin Associates, Ltd.