iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XI **Month of publication:** November 2021

DOI: https://doi.org/10.22214/ijraset.2021.38969

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Comparative Study between R-Pet & Virgin Pet in Terms of Technical Aspect and Market Potential

Dr. Sumanta Bhattacharya[1], Dr. Sparsha Moni Chatterjee[2], Monidipa Sarkar[3]

[1]*Research Scholar at MAKAUT , Public–Foreign-Defence Policy Analyst , C.E , CH.E , CCIO ,M.Tech (Chemical Processing in Textile Technology) , M.A in Development Studies, LLB , M.A in Security and Defence Law , DIA&D , DG&GS ,PGCPP&A , MPI(oxford University) ORCID ID : 0000-0003-2563-2787*

[2]*Ex Vice Chancellor of IIST Shipbur, Member of Executive Council AICTE ,Former Director of Technical Education, Chairman of BOAA,IIHT , Ministry of Textile (Govt of India).Member of Development commission (Govt of India).*

[3]*MBA (Textile Management), Sardar Vallabhbhai Patel International School of Textile Management, M.Tech (Chemical Processing in Textiles), Govt. College of Engineering & Textile Technology, Serampore*

Abstract: ***The crux of the new trend lies in sustainability and so follows the recyclable products. Polyester is of immense importance as a fibre when it comes to textile and garment, but the type used (Virgin PET) is not an eco-friendly one. Polyester filament extracted from the recycled PET bottles can cater to the unmet need of an eco-friendly substitute to the virgin polyester. A comparative study has been made to analyse whether recycled PET can perform the functionality of virgin PET. The physical properties of both stand out to be the same, signalling the use of recycled PET filament. Recycled PET filament finds it limitation in non-uniform dyeing but the same can be solved through chemical extraction.***

Keywords: Virgin PET, Recycled PET, Instron test, Boiling water shrinkage test, sustainable, market potential.

I. INTRODUCTION

Recycle today for a better tomorrow. For majority, recycling of PET bottle would mean placing the plastic bottles such as the normal water bottle, soda bottle, oil bottle, and other similar types into the blue recycling bin. For some, it means bringing the bottles to a recycling centre near you. While this ordinary token of "PET bottle recycling" is precise somewhat, a lot more advances are included before PET bottles can genuinely be recycled, processed into another item like polyester fibre, PET sheets/sheets, or back into a PET bottle. We are dealing with r-PET multifilament yarn which is having a big future market for upcoming Textile Era. Where Sustainable development is going to be the Oxygen for every invention, R-PET is becoming the best solution. Basically, different recycling process has different advantages with minimum challenges. We Can develop r-PET multifilament yarn as a best material for our daily uses from technical textile to apparel world. In order to maintain sustainability of our environment, R-PET multifilament yarn will be the Epoch-making invention for the Textile Industry.

II. OBJECTIVE OF THE STUDY

1) To Study the Process of recycling of polyester from PET bottles.
2) To study and check any deterioration in the Properties of polyester filament yarn made from recycled polyester vs virgin polyester.
3) To identify the Challenges in the properties of recycled PET filament yarn with respect to market.
4) To study the Market potential of recycled PET filament yarn.

III. METHODOLOGY USED IN THE RECYCLING OF PET-BOTTLES

Reprocess polyester can be manufactured using two types of approaches . It can be made through a chemical recycling route or it can be mechanically produced, which is the more common route. Mechanical Reprocess make use of clean plastic (polyethylene terephthalate) container which are also made using PET resin. The containers are scour , chipped, liquify and extruded into new PET fibers. The mechanical method uses post-consumer waste and less energy during processing. PET bottle reprocess is more empirical compared to other plastic waste streams because of the expensive plastic PET pitch. It is often a transparent material that's relatively pure and free from colorants and other functional additives. It must pass FDA requirements for food packaging, which eliminate the ability to add a lot of hazardous chemicals. Plastic bottles made to carry water and other soft drinks are made almost exclusively from PET, which simplifies the sorting process at the recycling facility.

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Chemical Recycling this method employs the use of chemicals to break down or decompose , the polyester material back to its original pyrrole , which can then be copolymerized back into new substance . The polyethylene terephthalate (PET) polymer is converted to its original ethylene glycol and terephthalic acid pyrrole via synthetic reactions. Once the PET polymers are polymerized back into PET resin and polyester, the resultant textile is identical from untainted polyester. The approach is quite expensive and mainly utilized for dyed and closed polyester by-product .

PET resin has a wide range of possible applications, including polyester fibre, food containers, and industrial-use film. Pantech is associated with PET bottle flakes and different other PET resin materials. While the recycling of pitch is a somewhat straightforward matter, the applications and grades of resin are extremely versatile. Pantech has a broad organization of clients inside and outside of Japan, so we can discover an end use for all types of resin materials to relate with its attributes.

1) *STEP 1:* Collection of PET recyclable material
2) *STEP 2:* Washing Flakes
3) *STEP 3:* Heating/Dehydrating
4) *STEP 4:* Polymerization/ filament or fibre manufacturing process
5) *STEP 5:* Dope dyeing or conventional dyeing process
6) *STEP 6:* Finished product

The method to manufacture PET bottle wafer from gathered bottles are flexible because the divergent squander streams are dissimilar in their configuration and standard . As far as machinery is concerned, there are many ways by which it can be done There are meanwhile many engineering enterprise which are contributing flake manufacturing plants and elements, and it's challenging to make a call for anyone or other plant design. Nevertheless, there are components which are providing many of those procedure . On the basis of configuration and defilement degree of the input substance , below given steps are followed.

a) Bale aperture and briquette aperture .
b) Classify and selecting dissimilar colours, foreign polymers especially PVC, pollutant matter, film transfer , paper, glass, sand, soil, stones and metals.
c) Washing before cutting.
d) Rough cutting and/or amalgamated with pre-washing.
e) Eliminating of stones, glass and metal.
f) Air shifting to remove film, paper and labels.
g) Crushing, dry and / or wet.
h) Erasing of low-density polymers (cups) under density differences.
i) Hot cleansing
j) Caustic cleansing.
k) Surface etching of Caustic, maintaining congenital consistency and fumigate .
l) Washing.
m) Clean water drench
n) Desiccating.
o) Air motion of flakes.
p) Machinery flake divide .
q) Water circuit and water treatment technology.
r) Flake standard Authority

IV. MATERIALS AND METHODS

A. *Materials*

Polyester Multifilament Yarn			
Sample No	Sample type	No of Filament	Denier
Sample 1	Virgin Polyester	36	150
Sample 2	R-PET Polyester	36	150

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B. Method

1) To ensure the properties of both Multifilament Yarn by developing stress-strain curve in order to compare the strength.

2) To find the Tenacity and Boiling Shrinkage for both the Sample. ¬

V. BOILING WATER SHRINKAGE TEST

A. Procedure

1) At first prepare a hank of polyester with the help of wrap reel

2) Then the so formed hank is knotted with the help of cotton yarn in few places

3) As the circumference of the wrap reel is 1m.

4) Then that hank of yarn is put in the boiling water & keep it for 30 min

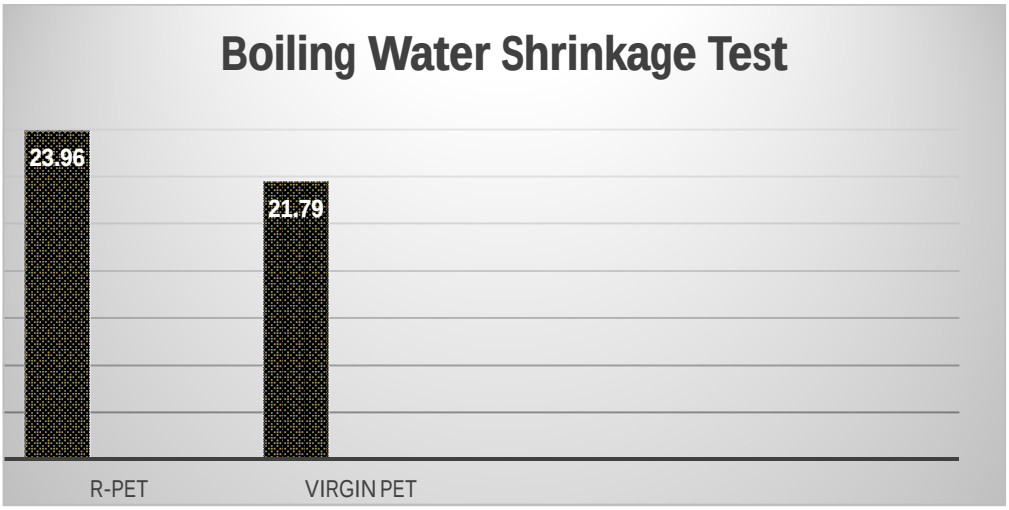
5) After that the hank of the yarn is dried & the final length of the hank is measured.

6) Now the boiling water shrinkage is measured by the following formula –

{(Initial length – Length after boiling)/ Initial length} ×100%

VI. RESULTS

MATERIAL TYPE	INITIAL LENGTH	AFTER BOILING LENGTH S_1	AFTER BOILING LENGTH S_2	AFTER BOILING LENGTH S_3	AVERAGE LENGTH AFTER BOILING	Boiling Water Shrinkage %
R-PET	69	51	53.6	52.8	52.46	23.96
Virgin PET	69	54.5	52.3	55.1	53.96	21.79



B. Instron Test

Procedure

1) At first a method is prepared in the Blue hill software with the following materials

*a) Speed :*300 mm/min

*b) Gauge Length:*500 mm

2) This test is carried out for both r-Polyester & Virgin polyester with10 sample each.

3) By the analysis of the graphs so made from INSTRON, we get the different loads on 10%,20%....to 100% extension of the yarn.

4) Then the following load points are expressed as by dividing these with the area.

5) Next by putting Stress Vs Strain, we get the Master curve.

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C. Instron Data And Result

1) 150 Den Black Virgin

SAMPLES	10%	20%	30%	40%	50%	60%	70%	80%	90%
S1	2.8	3.3	3.75	4.4	4.9	5.4	5.9	6.1	6.5
S2	3	3.3	3.6	4.1	4.6	5.15	5.5	5.85	6.1
S3	2.5	3.2	3.5	3.9	4.4	4.9	5.3	5.7	5.9
S4	2.8	3.3	3.8	4.2	4.8	5.5	5.8	6.05	6.13
S5	2.3	3.0	3.5	4.0	4.5	4.9	5.4	5.7	6.2
S6	2.4	3.0	3.5	4.0	4.6	5.1	5.6	5.9	6.25
S7	2.2	2.55	3.0	3.5	3.9	4.4	4.75	5.1	5.3
S8	2.5	2.85	3.35	3.7	4.15	4.6	5.2	5.5	5.7
S9	2.35	2.8	3.3	3.8	4.4	4.85	5.3	5.75	5.93
S10	2.1	2.6	3.1	3.6	4.45	4.85	5.3	5.7	6.0
Avg	2.495	2.99	3.085	3.92	4.47	4.965	5.405	5.735	6.001

Stress is divided by 0.01208; Strain=0.19004

2) Recycled Pet

SAMPLES	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
S1	2.55	3.05	3.45	3.8	4.25	4.75	5.05	5.4	5.5	5.54
S2	2.55	3.15	3.6	4.1	4.65	4.97	5.25	5.5	5.75	5.89
S3	2.53	3.2	3.7	4.25	4.7	5.1	5.4	5.6	5.9	6.03
S4	2.8	3.4	3.9	4.5	4.9	5.2	5.5	5.6	5.75	5.86
S5	2.8	3.45	4.1	4.65	5.05	5.5	5.75	5.9	6	6.08
S6	2.8	3.3	3.9	4.55	5.95	5.2	5.5	5.8	6	6.13
S7	3	3.5	4.05	4.55	4.9	5.4	5.6	6	6.1	6.26
S8	2.8	3.5	4.1	4.75	5.2	5.5	5.9	6.08	6.16	6.27
S9	3	3.5	4	4.5	5	5.5	5.85	6.09	6.2	6.36
S10	3.05	3.6	4.25	4.7	5.25	5.55	5.75	6	6.2	6.45
AVg	2.79	3.365	3.905	4.435	4.885	5.267	5.553	5.793	5.965	6.08

Stress divided by 0.01353; Strain=0.339

Polyester Type	Young Modulus	Work Factor	Boiling Water Shrinkage
Virgin PET	10750 N/mm^2	0.715	21.79%
R-PET	10166.67 N/mm^2	0.743	23.96%

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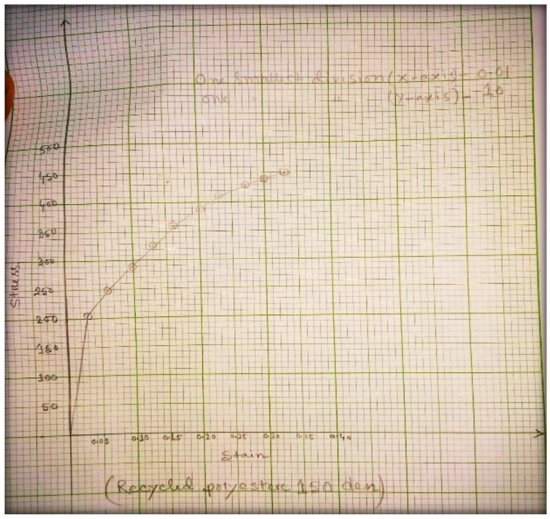
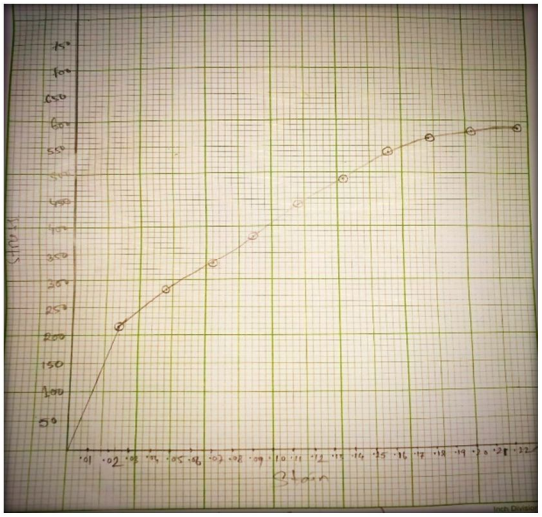
D. Stress-Strain Curve

100% RECYCLED PET



VIRGIN PET



VII. DISCUSSIONS

A. From the Instron and Boiling water Shrinkage Test

It is pretty clear that both recycled and virgin polyester are quite similar. Their master curves are quite similar so their Young's Modulus are 10750 N/m2 and 10166.67 N/m2, Work factor are 0.715 and 0.743 and their boiling water shrinkage % are 21.79 and 23.96 respectively for virgin PET and r-PET. So, property wise they are quite similar.

B. From Production Point of View

We really focus on recycle polyester filament manufacturing. As we know 80% of polyester market is dominated by polyester filament product. So, we want to replace virgin PET with r-PET filament. Filament production (1100m/min) which at first has to be randomly cut into required segments then we have to parallelise them by introducing series of process.

C. From Recycling Point of View

From polyester bottle we can extract polyester in two ways –

1) Mechanical Extraction

2) Chemical Extraction

As the PET bottles are collected from different sources. So, they have different varieties of polyester polymers so for mechanically extracted PET yarn has no Uniform dyeing or brightness guarantee. So, the market size of such materials are quite small. But for chemically extracted PET, PET bottles are converted into polyester monomer and oligomer and from there on filament yarn is produced so such yarn can provide uniform dyeing guarantee. But during chemical extraction due to the process and energy usage it involves cost so chemically extracted r-PET is 35% costlier than mechanically extracted r-PET.

VIII. MARKET POTENTIIAL

A. Textile fabrication is forwarding towards sustainability through reprocess polyester. This has resulted in the manufacture of reprocess polyester fibre using spin-offs from landfill and squander PET bottles. The order for reprocessed PET fibre is amplifying in the garments, fashion, and retail sectors.

B. The First world countries across the globe are promoting the idea of using reprocess polyester in many companies. Trade name are highly introducing reprocess polyester fabric pine made from plastic bottles in the garment spin off

C. In order to aid and promote reprocessing producers in the first world countries are concentrating on launching malleable bottle clarifying provision to produce reprocess polyester. The order for high quality reprocess PET filament is increasing as the textile industries are getting over with the problems for technical related to reprocess polyester such as complement pale shades and equalize in dyeing.

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IX. CONCLUSION

A. Recycle polyester multifilament yarn from PET bottle, is a new term for sustainable textile industry. From the above study, it can be concluded that we can replace virgin polyester with recycled polyester as their physical properties are quite similar. Except this, we see that there is a lot of issue with r-PET multifilament yarn. There is an issue of dyeing uniformity with respect to extracting PET by Mechanical process.

B. Most important thing regarding r-PET filament that it can be used for both the cases in where dyeing uniformity is not needed. Production process for r-pet filament with respect to virgin PET filament is comparatively lower as we are extracting this from collected recycled PET bottle.

C. Finally, we can have a better opportunity to implement r-PET filament yarn market in INDIA though some of our industries are already looking forward for this green initiative.

D. As per our study, it is clear that r-PET filament is going to be an extra-ordinary initiative for future textile industry market depending on the sustainability as well as technical aspect.

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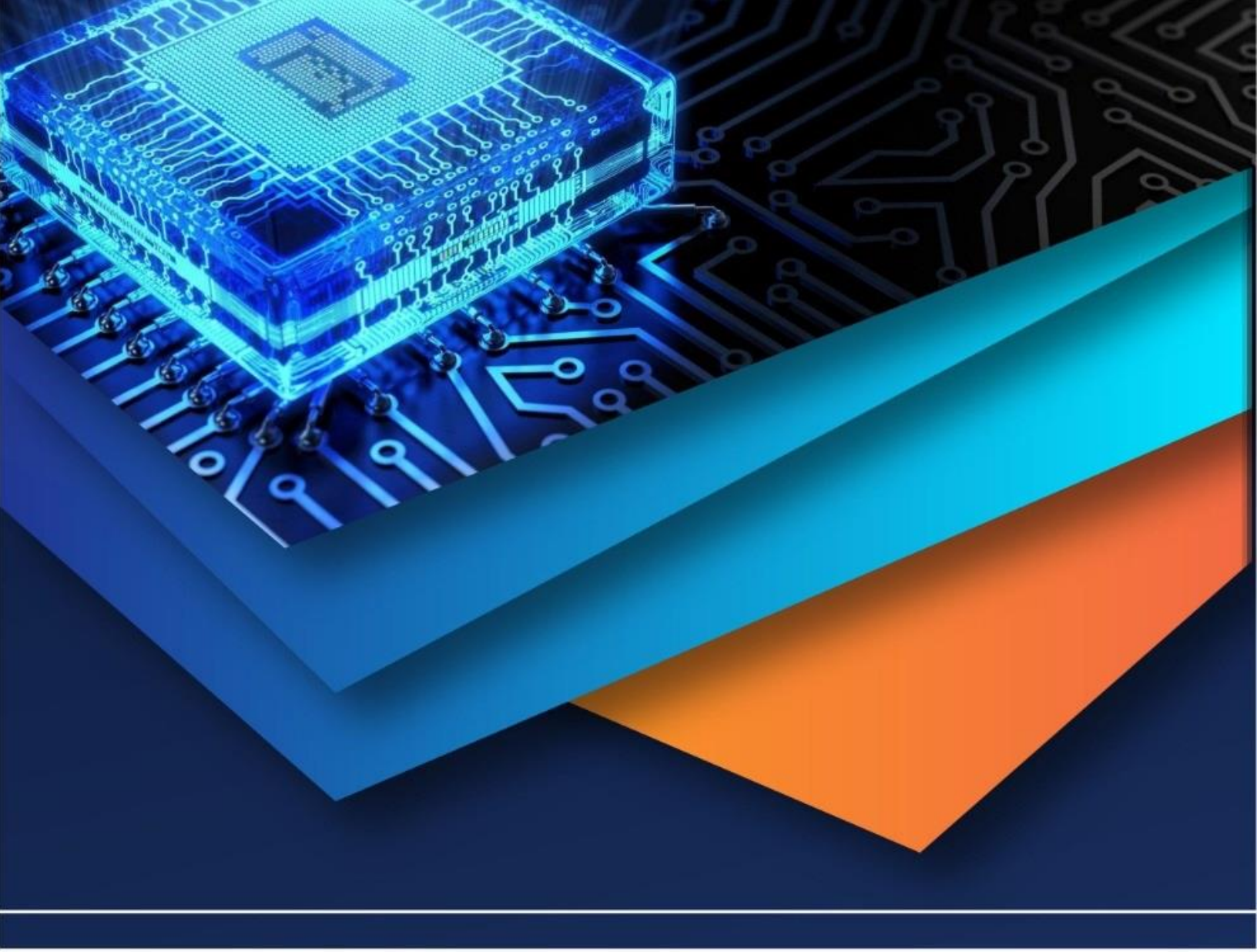

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