USE OF NEEDLE FELT IN SLOW SAND FILTERS
Part I. Methodology and Procedures.

إستخدام لباد الابر في مرشحات الرمل البطيئه
الجزء الاول : الطريقه والاستخدام

By

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الخلاصة : تعتمد فكرة الترشيح باستخدام المرشحات الرملية البطيئة (المرشحات الانجليزية) على وجود الكثير والعديد من الانواع المختلفة من الكائنات الحية الدقيقة والتى تكثر على سطح الرمل مكونه ما يطلق عليه طبقة التلوث وهى طبقة تكون مسئولة على تحليل المواد العضوية وحجز المواد العالقة الموجودة بالمياه الغير مرشحة.

ويقدم هذا البحث قماش غير منسوج ذو تركيب خاص يستخدم كطبقة يعلق بها جزء من طبقة التلوث ويمكن رفعه واعاده استخدامه أكثر من مره دون انتظار لفترة نضج جديدة بعد كل عملية غسيل للمرشح.

ثبت أن خواص المياه الغير مرشحه (الخام) في المرشحات الرملية البطيئة المزودة بالاقمشة الغير منسوجة قد تحسنت مقارنة ببقية المرشحات الأخرى الموجودة بمحطة الترشيح بمدينة سندوب — المنصورة.

الاقمشة القطنية المنسوجة ثبت فشلها فى الاستخدام نتيجة تحللها تماما بعد ٢٨ يوم من الاستخدام ، بينما الاقمشة الغير منسوجه من الياف البولي استر ثبت نجاحها فى الاستخدام لفترة وصلت الى ٥٤ يوم ومازالت تستخدم حتى الآن.

الأقمشة الغير منسوجة المستخدمة فى هذا البحث ثبت انها لا تعوق معدل السريان وتحافظ على تصرف المرشح (٤,٣٥ — ٦,٥٢ م٣/م٢/يوم).

ثبت أحصائيا معنوية خواص المياة المرشحة باستخدام الأقمشة الغير منسوجه، والاختبارات التى أجريت على المياه (الخام ، المرشحه) هى :

١— النسبة المئوية لعكارة المياه.
٢— الخواص الحمضية — القلوية للمياه.
٣— نسبة البكتريا المزالة.
٤— نسبة الطحالب المزالة.

Abstract

The use of textile fabrics is a good contribution in slow sand filters, and useful to civil engineering, and truley an addition to the technology of water filteration by this method.

It has been proved that by using woven filter fabrics the thickness of removed sand decreased by 1 Cm — 15 Cm, while this thickness

reached to 0.5 Cm only by using nonwoven packed filter fabrics (without these fabrics the thickness of removed sand reached to 2 Cms.).

Also it has been proved that the quality (or the properties) of the raw water when using packed filter fabrics improved remarkably in slow sand filter when compared with other filters which does not contain these fabrics.

The woven cotton fabrics (single layer filter) failed in these experiments and decomposed completely after 28 days of use while packed filter fabrics (polyester fabrics) succeeded and continued for approximately 54 days.

The fabrics used in the present work showed no resistance to water flow rate in the filter, and it's properties are suitable for the filteration process (4.35 – 6.52 m^3/m^2/day, which considered normal discharge in slow sand filters).

The following water properties were measured and evaluated:

1. Turbidty removal
2. Algae removal
3. Bacterial removal
4. Values of Alk. and pH.

KEYWORDS:

"Schmutzdecke" = Contaminated layer, packing density coefficient (Ø), the porosity of filter (n%), Slow Sand Filter (SSF), Compact Units (CU), and NW = Nonwoven Fabric.

AIM OF THE PRESENT WORK:

An older kind of sand filter is the slow or English type. Here, no coagulant is added and the filters has to be "ripened" until a "Schmutzdecke" of sediment and bacterial growth is formed on the surface, before good filteration could be effected(3). When the slow sand filter requires cleaning, the upper layers of sand are shoveled off, taken out washed, and then relaid on the filter bed.

The aim of the present work is to study the possibility of using textiles as a filtering component in the slow sand filter, to carry the contaminent layer and prevent it from precipitation on the sand filter without blocking of it's pores, and reduces the cost of removed sand after each cleaning process for the filter, also to keep a part from the contamination layer inside the internal structure of the fabric, this would help in reducing the maturity duration of the contamination layer.

The use of textile fabrics is a good contribution in slow sand filters, and useful to civil engineering, and truley an addition to the technology of water filteration by this method.

INTRODUCTION:

The greatest use of filters in civil engineering is in the form of single layer, or packed filters. Such a filter consists of a single layer of textile woven from natural, synthetic, metal or glass fibres. As the filter operates, it collects particles in the interstitial spaces between the fibres, these particles improve the collection efficiency greatly. During the rest of the useful life of the filter, this interstitial "Schmutzdecke" will remain in place. Filters containing such as interstitial "Schmutzdecke" layer and with no holes present other than the pores give excellent collection efficiencies when operating at the low water velocities typical of single-layer-filter applications. As the filter continues to operate, a "Schmutzdecke"cake forms on the upstream side of the filter. This "Schmutzdecke" cake improves the collection efficiency slightly and increases the pressure drop greatly. Eventually, as the cake becomes thicker and thicker, the pressure drop becomes so high that the filter must be withdrawn from service and the cake removed. A variety of methods have been devised for the removal of the "Schmutzdecke" cake, most of these involve either shaking the cake loose from the filter or blowing the cake away by a reverse flow of air. When the cake has been removed, the filter is placed back in service and the cycle is repeated.

Figure 1 shows a section of the textile filter cloth with an interstitial "Schmutzdecke" layer and a "Schmutzdecke" cake present.

GENERAL CLASSIFICATION OF INDUSTRIAL FILTER FABRIC:

Filters can be classified as one of two types, based on the way in which the fibres are held in place. In the first type, the packed filter (Nonwoven filter cloth), the fibres are loosely packed into a substantial volume, prsenting a fairly long path along which water must pass on its way through the filter. In the second type of filters, called the single-layer filter, fibres are woven into a thin layer of cloth, for example. Figures (2a and 2b) show a packed filter, and a single-layer filter respectively (1).

Methodology and Procedures:

A. Intake:-

The pilot plant receives the raw water from Sandoop Compact unit intake, chamber. The raw water is pumped to the distribution chamber by means of two pumps that are operated alternatively..

B. Distribution Chamber:-

Raw water is distributed to the upflow roughing filter or the slow sand filters by gravity from the distribution chamber.

C. Slow Sand Filters:-

The pilot plant also includes four reinforced concrete pipes, each with 3.25 m in height and 2.25 m. in diameter, used as slow sand filters.

Raw water is distributed to sand filters from the upflow roughing filter or directly (i.e. without pretreatment). The filter No. 4 is provided with tested single-layer and or packed filter fabric and float valves at both the inlet and the outlet of the filter, in order to regulate and control the flow rate and to adjust head of water on the filter (4). (See Figure 3).

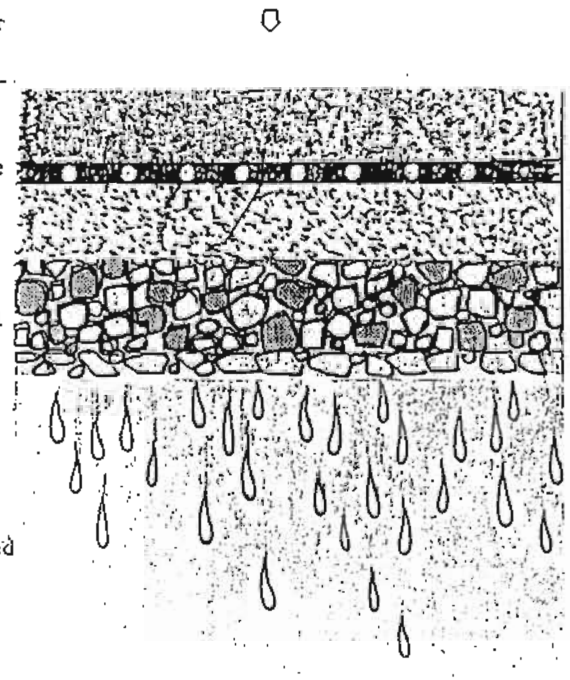

Fig. 1: Single—layer filter or packed filter with interstitial "Schmutzdecke" layer and with cake attached.

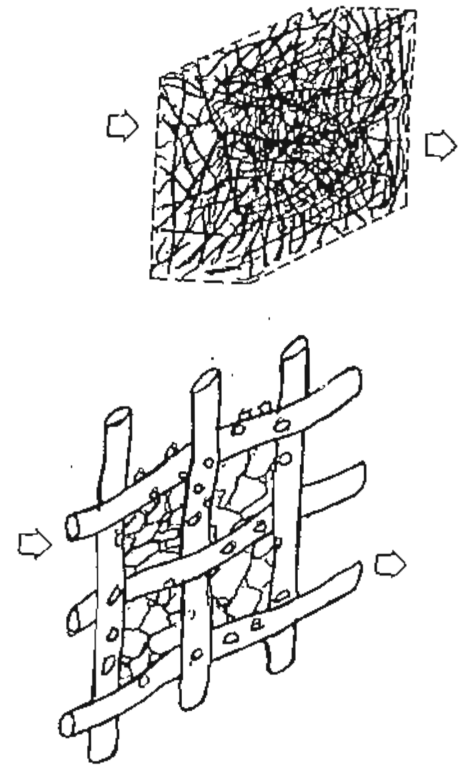

Fig. 2: Filter element: (a) Packed filter, and (b) Single—layer filter (1).

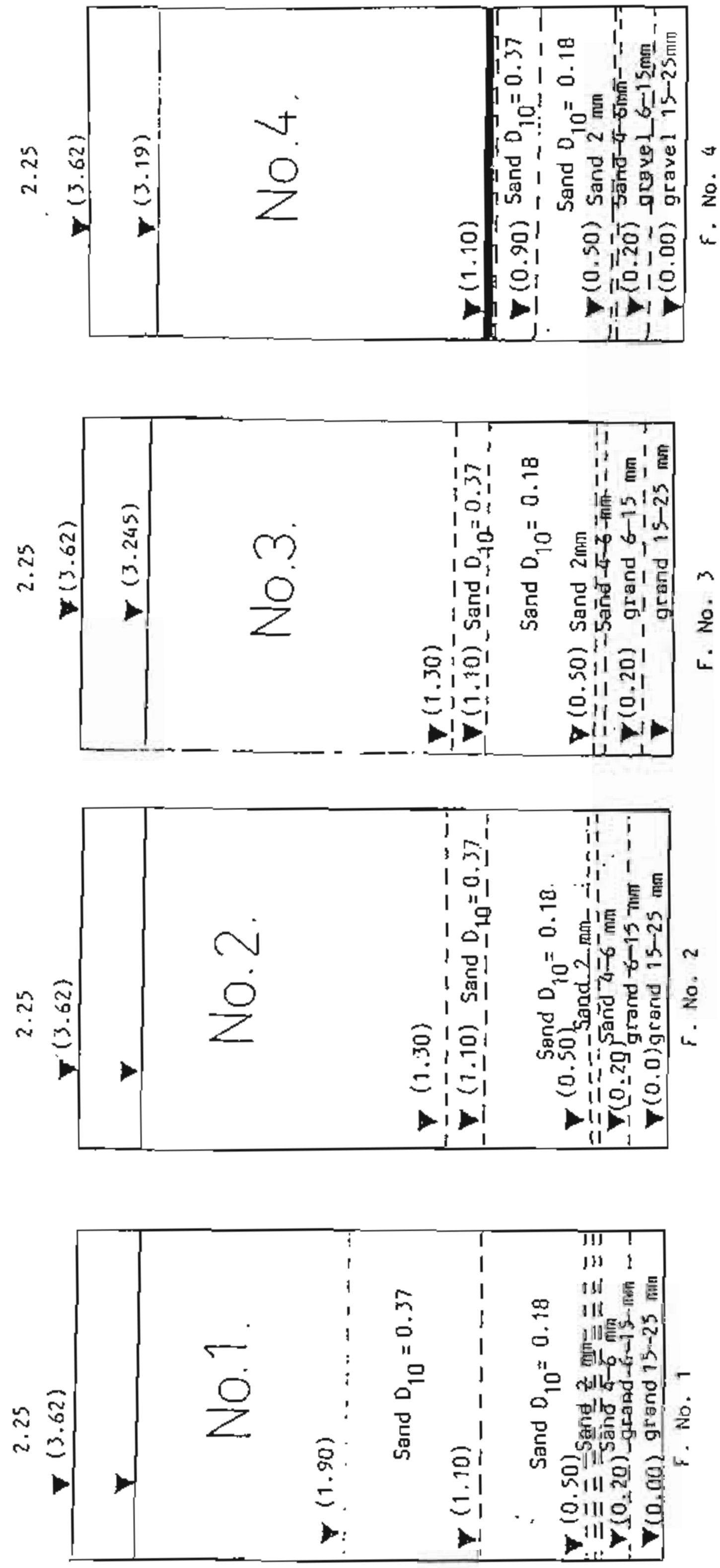

Fig. 3: Shows the arrangement of sand, gravel, and textile in Slow Sand Filter Station.

The following table summarizes test conditions:

Table 1: Run No. 1 – 5, Test conditions.

Run No.	Depth of sand (m)	Eff. Size of sand (mm)	$(m^3/m^2/d)$	Head (m)	Notes
1	0.50	0.18	4.35	1.4	Without URF
2	0.4 + 0.2	0.18 + 0.37	4.35	1.4	" URF, with woven fabric (1)
3	0.4 + 0.2	0.18 + 0.37	4.35	1.4	Without URF, with woven fabric (2)
4	0.2 + 0.4	0.37 + 0.18	4.35	1.4	Without URF, with nonwoven (1)
5	0.2 + 0.4	0.37 + 0.18	4.35	1.4	Without URF, with nonwoven (2)

The purposes of the run No. 1 were to test the physical plant and evaluate its performance at two filter rates; 4.35 and 6.52 m^3/m^2/day, with and without pretreatment by upflow roughing filteration (URF).

Filter No. 4, with no pretreatment and without using textiles, clogged within 5 days and yielded no meaningful results. It was found that the thickness of removed sand reaches to 2 Cm.

The purposes of run No. 2 were to investigate:-

1) Use of a woven cotton fabric over coarse and fine sand media, without pre-treatment, and
2) Cercaria removal.

Filter No. 4, with no pretreatment, and using a woven cotton fabric over the media ran for only 3 days with inclusive results as to the use of fabric.

The early clogging of Filter 4 confirms that pre-treatment is required to achieve acceptable length of filter run.

The filter 4 was effective in removing 100% of the cercaria.

It was found that the thickness of removed sand decreased from 1.5 – 1 Cm.

The purpose of run No. 3 were to further investigate:-

1) Coarse and fine sand covered by polyester nonwoven fabric (Filter 2),
2) Confirmation of the need for pretreatment (Filter 4).

Filter 2, with polyester nonwoven fabric (needle punched) over the filter media, ran for 12 days before a pump failure rendered the run inconclusive.

Bacteriological removals were considerably reduced and ranged from 87 to 98% (note that removals in Filter 2 without nonwoven fabric in run 2 was in the range from 96 to 98%).

Filter 4, with no pretreatment, ran only 4 days, and confirmed our earlier opinion, pretreatment is mandatory.

The purposes of run No. 4 were to continue investigations as follows:-

1) Continue testing textile fabrics over the sand (Filter 4),and
2) Start evaluation of declining rate filteration.

Filter 4, testing the woven cotton fabric ran for 21 days before terminated by the decomposition of cotton fabric.

Turbidity removals, the first five days of operation ranged from about 92 to 96%, not as good as in previous runs.

Table 2 summarizes the turbidity removal rates to date and provides a numerical rating for comparision of filter efficiencies, and Tables 3 and 4 indicates the algae and bacteriological removal rates respectively.

Table 5 shows our estimates of the comparative removal efficiency for filter runs 2, 3, and 4. (Run No. 1 was excluded based on the longer filter runs achieved using coarse and fine filter sand).

The purpose of the run No. 5 was to try to complete our evaluation of nonwoven fabric covering the filter media. This run involved Filter 4 with 20 Cms of coarse sand and 40 Cms of fine sand at a rate of 4.35 m^3/m^2/day on pretreated water. The fabric tested was reinforced laminated nonwoven, polyester fabric, the test lasted 40 days.

Table 2: Turbidity Removal Range and Comparative Ratings.

Run No.	Filter No.	Turbidity Removal (%)	Flow ($m^3/m^2/day$)	Rating *
1	4	–	–	–
2	2	90 – 93%	6.52%	4
3	3	94 – 98%	4.35	1
4	4	92 – 97%	4.35	3

Table 3: Algae Removal Ranges and Comparative Ratings.

Run No.	Filter No.	Algae Removal (%)	Flow ($m^3/m^2/day$)	Rating *
1	4	–	–	–
2	2	95 – 98%	6.52	1
3	3	73 – 93%	4.35	5
4	4	91 – 94%	4.35	6

Table 4: Bacterial Removal Ranges and Comparative Ratings.

Run No.	Filter No.	Bact. Removal (%)	Flow ($m^3/m^2/day$)	Rating *
1	4	–	–	–
2	2	94 – 99%	6.52	2
3	3	87 – 98%	4.35	5
4	4	98%	4.35	3

* Comparative rating of filter based on removal efficiency.

Table 5: Comparative Ratings (Turbidity, Algae and Bacteriological removals).

Run Filter	Filter Sand (Cms)	Turb. Removal	Algae Removal	Bact. Removal
Run 4 Filter 2	20** 60*	4	1	2
Run 4 Filter 4	20** 40*	4	3	3
Run No.	**Filter No.**	**Turb.**	**Algae**	**Bact.**
2	2	4	1	2
3	3	1	6	6
4	4	3	3	3

* Fine sand, ** Coarse sand.

Turbidity removal was generally good but erratic. Most values ranged between 94% and 98% but there were several readings below 94%.

Algae removals ranged from 76 to 86%, lower than most of the previous runs.

Bacteriological removals, ranging from 86 to 98% were also lower than most of the previous runs. In comparison with Compact Units, turbidity and algae removals for the Slow Filters with Nonwovens was better and more consistent, but bacterial removals were not conclusive for this run. Figure 4 provides data on performance.

The thickness of removed sand after run No. 5, reached 0.5 Cm only.

TEST SAMPLES:

Four woven and nonwoven textile fabrics were used. The fabrics are made from staple cotton fibres and staple polyester (ρ = 1350, and 1380 Kg/m^3 respectively). Their identification number and main characteristics are presented in Tables 6 and 7. They represent a great range of mass per unit area 100 to 1800 g/m^2 and of thickness 0.4 to 13.4 mm.

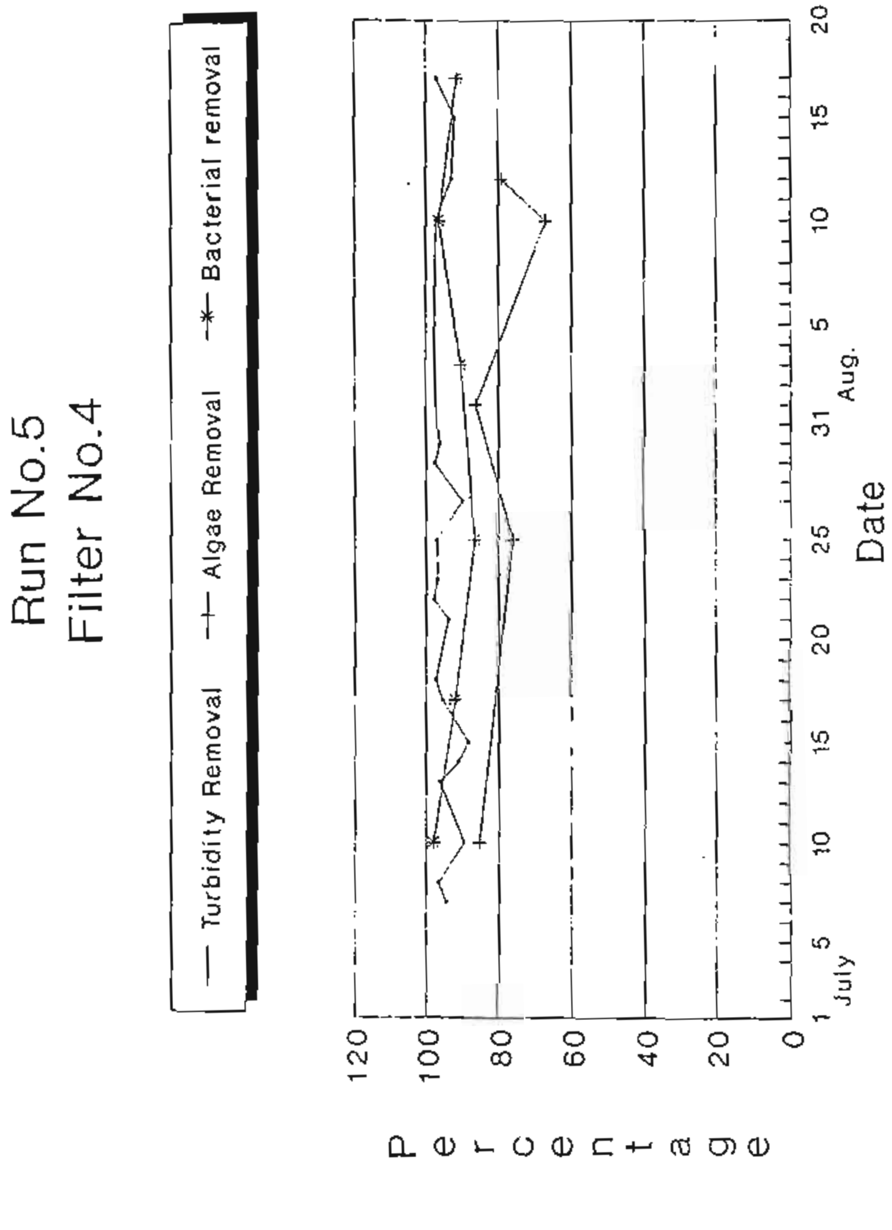
Run No.5
Filter No.4
Turbidity Removal
Algae Removal
Bacterial removal
Percentage
120
100
80
60
40
20
0
1
5
10
15
20
25
31
5
10
15
20
July
Aug.
Date

Figure No. 4

Table 6: Single-layer Filter Cloth Cahractersitics.

Fabrics / Properties	Mass per unit area (gm/m^2)	Thickness (mm)	Calculated pore size (n%)	Packing density (Ø)
Satin Fabric (5/3)	100	0.40	83.7	0.163
Plain Fabric (1/1)	158	0.56	81.6	0.184

Table 7: Packed Filter Cloth Characteristics.

Fabrics / Properties	Mass per unit area (gm/m^2)	Thickness (mm)	Porosity (n%)	Packing density (Ø)
Needle Punched (reinforced NW) (1)	550	2.00	80.0	0.199
" " (2)	600	2.50	82.6	0.174
" " (3)	650	2.80	83.2	0.168
" " from textile waste	1800	13.40	90.3	0.097

DISCUSSIONS

Mechanically bonded nonwoven fabrics (packed filter), with low punching density and of high surface hairiness, high mass/unit area (high thickness) were found to be suitable for use in slow sand filters for the following reasons:

1- The fabric is considered as multi-layer filter, since each layer forming the batt of fibres acts as a seperate filter. This would increase the efficiency of the filter in filtering the water.

2- The high thickness of the packed filter fabric,which reaches to 1.34 Cm, give a chance to bacteria growth in the pores of the fabric and on the fibres protruding on fabric surface, which in turn reducing the maturity period of the contaminant layer, and helps in maintaining it partially after the washing process of filter, this enables in the filteration process.

3- In the case of existance of cercaria in the raw water, thick fabrics limited the capabilities of the cercaria from penetration through the fabric, and the propability of its death during penetration trails is high, because of the random pathes inside the fabric, and if moved horizontally the fabric will be a grave.

CONCLUSIONS

The use of Nonwoven in filters or for filteration purposes is not new, but it's use with sand and gravel as a basic component in Slow Sand Filters is a contribution from the textile side in serving the civil engineering.

PROGRAM FOR FURTHER INVESTEGATION

Based on the positive results from our study to date we plan to proceed as follows:

1) Continue evaluative of nonwovens, chemically-mechanically, bonded nonwovens, and also nonwovens out of textile waste, for filter covering.

2) Most suitable raw material, structure and best methods for producing these fabrics to suit this purpose.

3) Start work on the economicas of Slow Sand Filters using textiles versus Slow Sand Filters without textiles and also versus Compect Units.

4) Continue investigations on Cercaria removals.

5) Make additional filter runs at a rate of 6.52 m^3/m^2/day.

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