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Project Summary

Logan Wash Field Treatability Studies of Wastewaters from Oil Shale Retorting Processes

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Treatability studies were conducted on retort water and gas condensate wastewater from modified *in-situ* oil shale retorts to evaluate the effectiveness of selected treatment technologies for removing organic and inorganic contaminants. At retorts operated by Occidental Oil Shale, Inc., at Logan Wash, Colorado, treatability studies were conducted on retort water using filter coalescing, steam stripping, activated sludge treatment (both with and without powdered activated carbon addition), sand filtration, and granular activated carbon adsorption. Retort water had high concentrations of ammonia-nitrogen, total Kjeldahl nitrogen, alkalinity, dissolved organics, phenols, sulfide, total dissolved solids, boron, potassium and sodium. Steam stripping removed ammonia-nitrogen, alkalinity, and sulfide from retort water and organics removal was low. Gas condensate wastewater had high concentrations of ammonia-nitrogen, total Kjeldahl nitrogen, dissolved organics, alkalinity, phenols, sulfide, and pyridine compounds. The overall scheme for the gas condensate treatment removed ammonia-nitrogen, total Kjeldahl nitrogen, alkalinity, sulfide, biochemical oxygen demand, dissolved organic carbon, chemical oxygen demand, and phenols.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

To assess the characteristics and treatability of wastewaters generated from the processing of oil shale, the U.S. Environmental Protection Agency (EPA) contracted with Monsanto Research Corporation (MRC) in 1979 to conduct a five-phase program entitled "Assessment of Oil Shale Retort Wastewater Treatment and Control Technology." The program had the following objectives (phases):

- I Summarize available information concerning oil shale retort wastewater sources and characteristics;
- II Identify control technologies that are potentially applicable for treatment of the identified wastewater streams;
- III Design pilot-scale units capable of evaluating the applicable technologies at oil shale processing sites;
- IV Construct the pilot-scale units; and
- V Operate the units and evaluate treatment technology performance.

Based on the results of Phases I and II, it became apparent that not much information existed on which to evaluate and select potentially applicable technologies for testing and that laboratory bench-scale testing and wastewater characterization were warranted. Wastewater characterization and bench-scale treatability studies were conducted using samples of oil shale wastewaters available at the time. Steam stripping, hyperfiltration, carbon adsorption (batch isotherm and column), and activated sludge treatment tests were conducted on a bench-scale level. The results of these studies and the information previously collected during Phases I and II were used to select the treatment schemes and units for construction and field testing under the follow-up Phases III through V. The schemes and units approved by EPA with some modifications were field tested at the modified *in situ* retorts operated by Occidental Oil Shale, Inc., in Logan Wash, Colorado.

Oil shale retorts generate gases and an oil/water mixture from shale pyrolysis, combustion of carbonaceous residues, and decomposition of inorganic carbonates. As shown in Figure 1, off-gases generated from an *in-situ* retort exit the retort bottom and are brought to the surface for treatment. The retort oil/water mixture accumulates in the product collection sump at the retort bottom and is subsequently pumped out and treated to recover the bulk of the shale oil. The separated gas condensate and retort waters are the wastewaters which were studied at the Logan Wash field site.

At Logan Wash, treatability studies were conducted for three weeks on retort water using filter coalescing, flocculation/clarification, and steam stripping technologies (Figure 2). Also, studies were conducted for 14 weeks on gas condensate wastewater using filter coalescing, steam stripping, conventional and powdered activated carbon (PAC) activated sludge treatments, sand filtration, and granular activated carbon adsorption technologies (Figure 3).

The test equipment and supporting field laboratory for conducting the treatability studies were either provided by EPA or procured by MRC. Equipment layout at the trial location is shown in Figure 4. Analytical methods utilized adhered to Standard Methods when applicable.

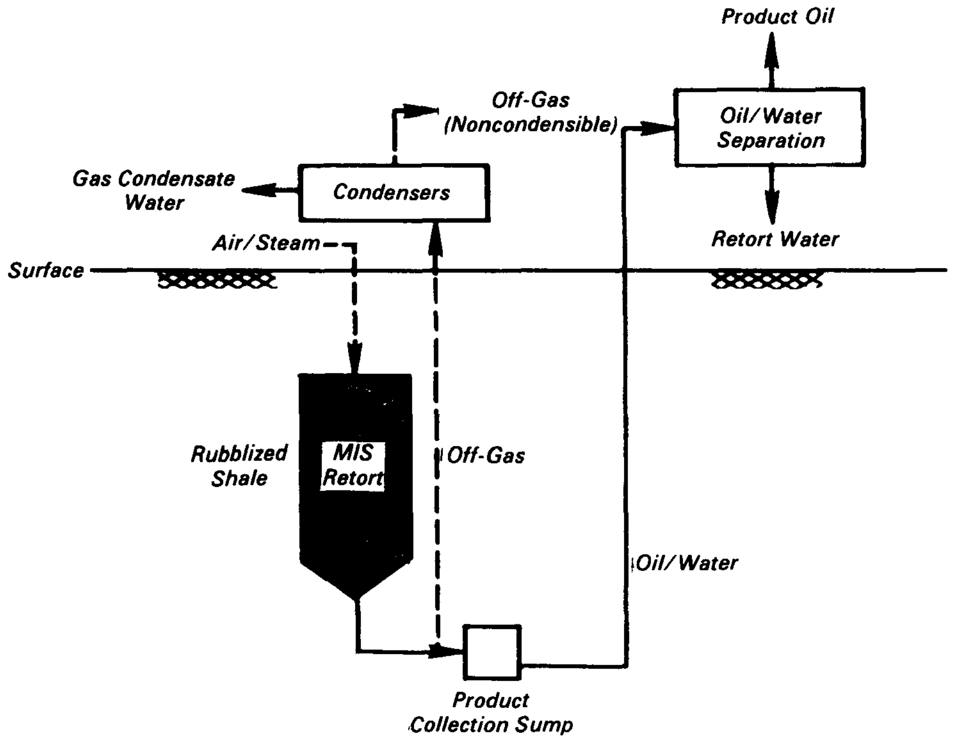


Figure 1. *Production of gas condensate and retort waters by modified* in-situ *(MIS) retorting.*

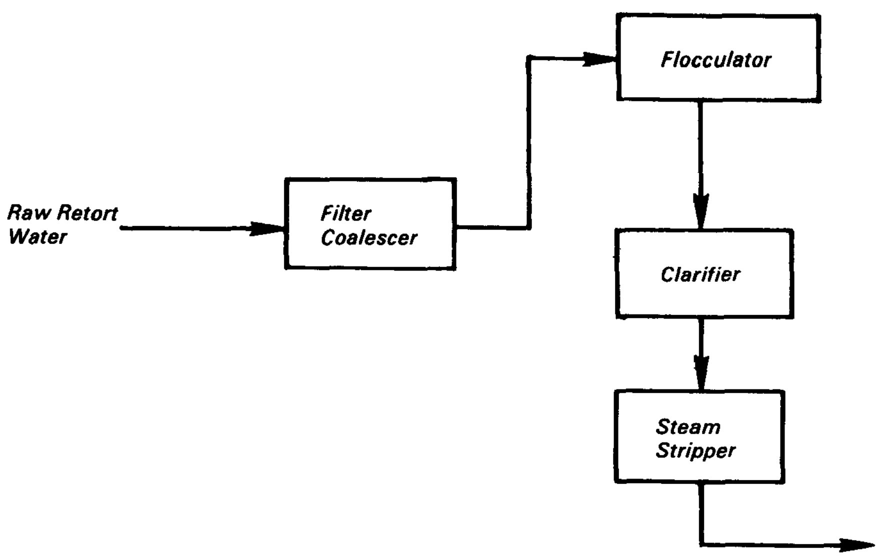


Figure 2. *Retort water treatment scheme.*

Test Results

Retort Water - Overall Treatment

Retort water was treated primarily to remove oil and grease, suspended solids, ammonia, and alkalinity. The filter coalescer, flocculator/clarifier, and steam stripper in series were used to remove these pollutants. The overall treatment scheme was very effective for ammonia and alkalinity removal (Figure 5). Relatively high sulfide, TKN, and phenols removals were also achieved. Due to low levels of oil and grease, and suspended solids, the scheme was not effective in removing these pollutants.

Gas Condensate - Overall Treatment

Filter coalescing, steam stripping, conventional activated sludge treatment, sand filtration, and GAC adsorption comprised the overall treatment scheme for the gas condensate. The scheme was very effective in removing ammonia, organics, sulfide, alkalinity, and solids from the gas condensate. Assuming conditions listed below, the scheme would produce a final effluent with the expected composition presented in Table 1.

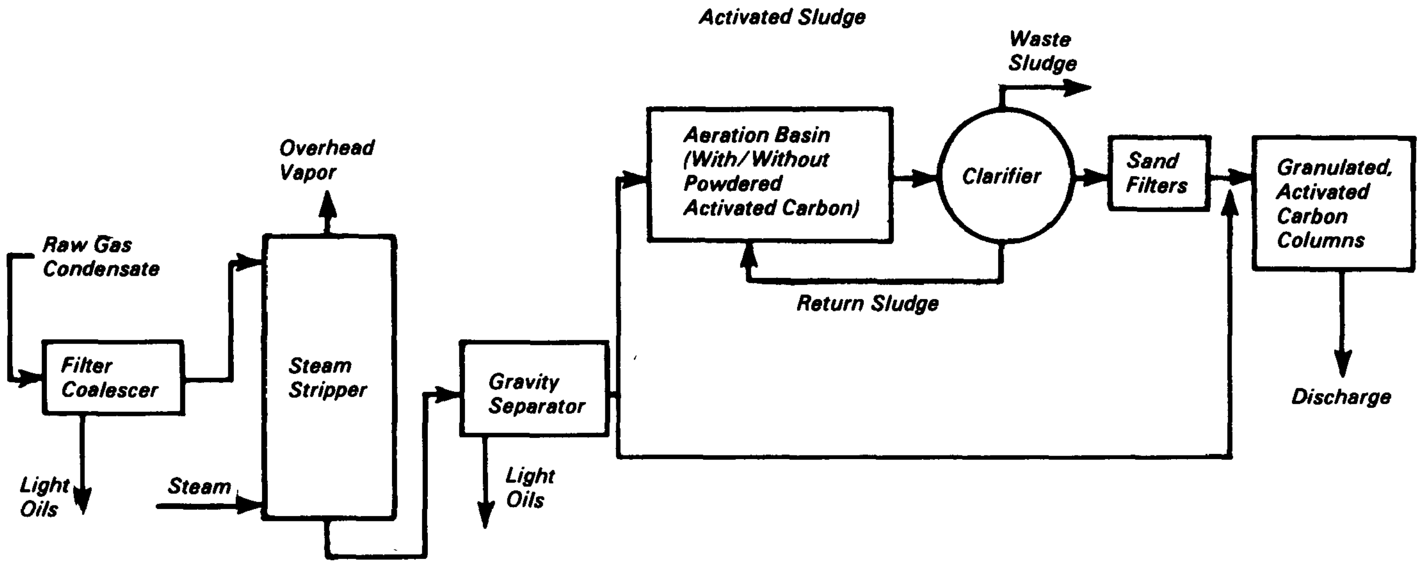


Figure 3. Gas condensate wastewater treatment schemes.

Steam stripper:
GL/ratio = 0.15 kg/liter (1.2 lb/gal)
Activated sludge system:
Hydraulic retention time = 16 hours
Sludge age = 32 days
GAC column:
Contact time = 19 minutes

The other treatment scheme comprised filter coalescing, steam stripping, and GAC adsorption. The scheme was effective in removing ammonia, organics, sulfide, alkalinity, and solids from the gas condensate. But, the performance of granular activated carbon adsorption was relatively poor and this scheme was less effective in removing pollutants than the one with an activated sludge system included.

Conclusions

Pilot-scale field treatability studies on real-time oil shale wastewaters from Occidental *in-situ* MIS retorts demonstrated that retort water had high concentrations of ammonia, TKN, alkalinity, dissolved organics, phenols, sulfide, and TDS; and gas condensate had high concentrations of ammonia, TKN, dissolved organics, alkalinity, phenols, and sulfide. Steam stripping was effective in removing ammonia and alkalinity from the retort water. Steam stripping, activated sludge treatment - both conventional and PAC, sand filtration, and GAC adsorption were effective in removing ammonia, alkalinity, TKN, nitrate, soluble COD, soluble BOD_5, DOC, phenols, sulfide, and TSS from the gas condensate.

Pollutant removal efficiencies across individual treatment units for retort water and gas condensate treatment schemes are presented in Tables 2 and 3, respectively.

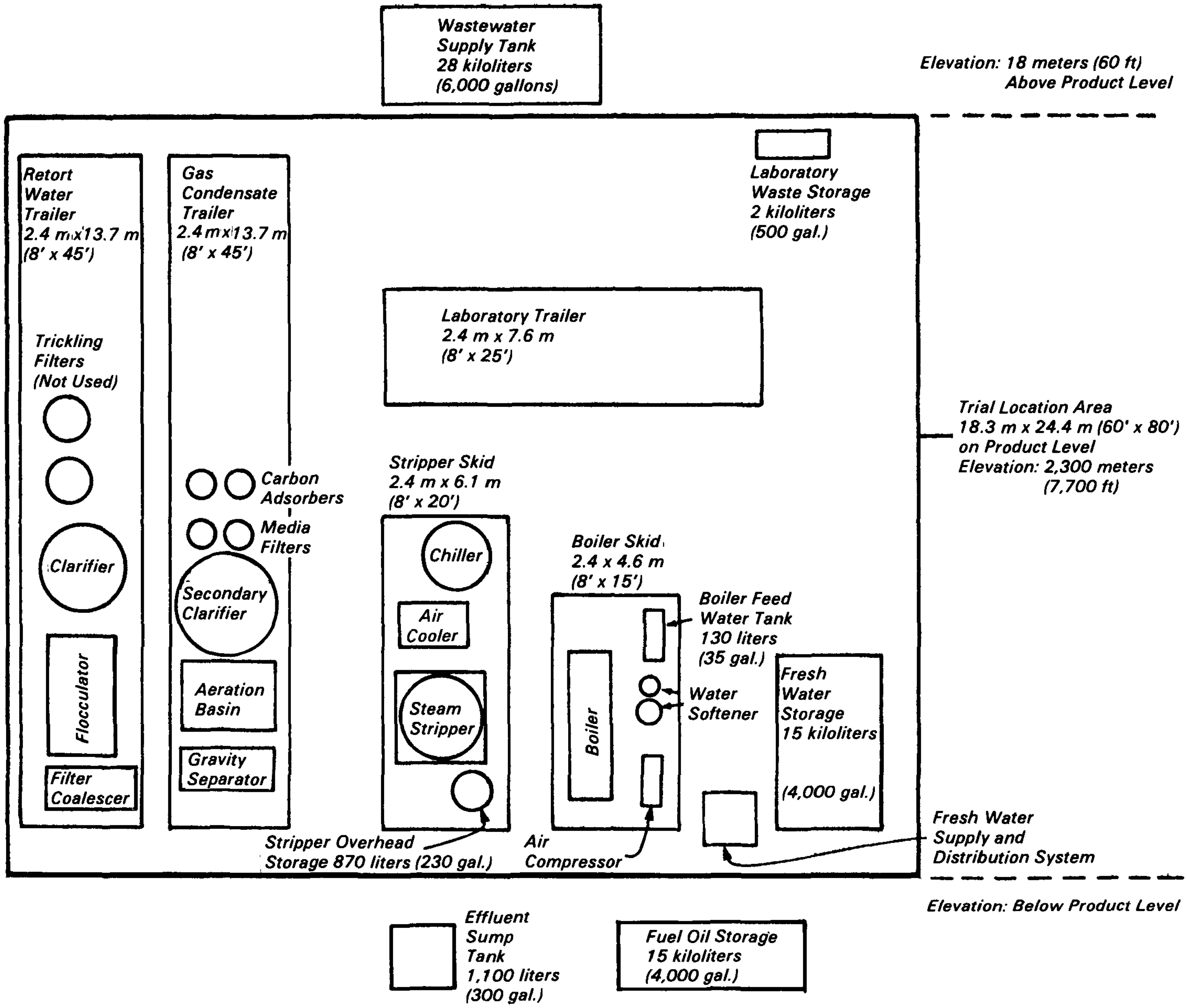
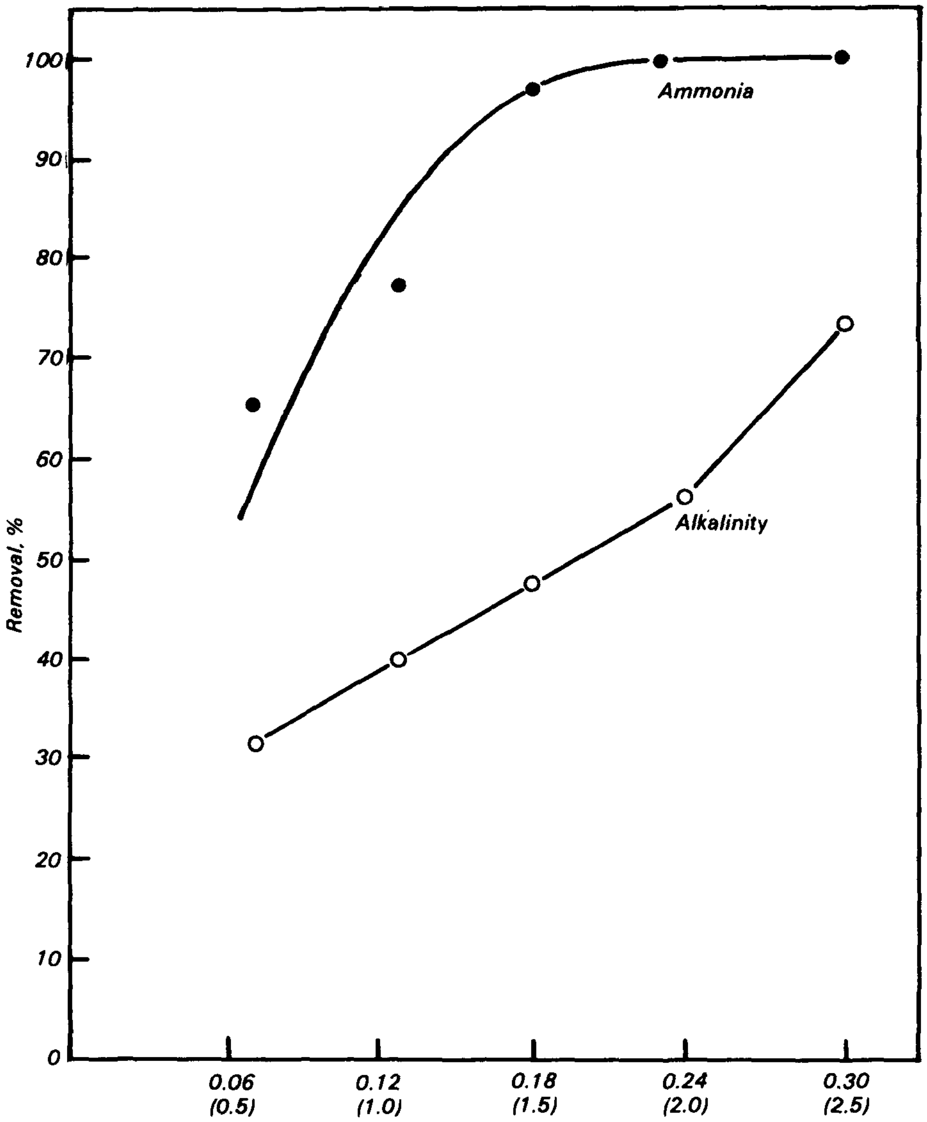


Figure 4. *Equipment general layout at the trial location.*



G/L Ratio, kg/steam/liter feed water (lb steam/gallon feed water)

Figure 5. *Percent ammonia and alkalinity removal from retort water as a function of G/L ratio in the steam stripper.*

Table 1. *Overall Gas Condensate Treatment Scheme Performance Summary*

Parameter	Concentration, mg/L		Percent removal
	Raw wastewater	Final effluent	
NH_3-N	9,000	90	99
TKN	6,800	180	97
NO_3-N	1.1	0.4	64
Soluble COD	2,700	50	98
Soluble BOD_5	800	20	98
DOC	890	25	97
Phenols	120	0.02	100
Sulfide	72	2	97
TSS	7	5	29
VSS	5	5	0
Alkalinity as $CaCO_3$ to pH 4.5	31,000	350	99
pH[a]	8.5	7.5	NA[b]
Oil and grease[c]			

[a]Standard pH units.
[b]NA - not applicable.
[c]Oil and grease were at low levels (average 18.6 mg/L) in the gas condensate received for testing; however, an oil and grease removal treatment step may be necessary if the raw gas condensate has a relatively high oil and grease level.

Table 2. *Pollutant Removal Efficiencies Across Individual Units for Retort Water Treatment Scheme*[a,b]

Parameter	Filter coalescer	Flocculation clarification[c]	Steam stripper[d]
Oil and grease	6		
Ammonia			97
TKN			88
Soluble BOD_5			5
DOC			4
Phenols			32
TSS	21	0	
VSS	20		
Alkalinity as $CaCO_3$ to pH 4.5			47
Fluorides		7	
Chlorides		11	

[a]Average removal efficiencies are reported.
[b]Blanks indicate data not collected.
[c]Lime dosage at 90 mg/L.
[d]G/L = 0.18 kg/L (1.5 lb/gal).

Table 3. *Pollutant Removal Efficiencies Across Individual Units for Gas Condensate Treatment Scheme*[a,b]

Parameter	Treatment unit				
	Filter coalescer	Steam stripper[c]	Activated sludge treatment[d]	Sand filter	GAC adsorption column[e]
Oil and grease	28				
Ammonia		99	6		
TKN		96			
Soluble COD		56	59		95
Soluble BOD_5			91		70
DOC		60	52		89
Phenols		29	93		99.5
Sulfide		97			
TSS				70	
Alkalinity as $CaCO_3$ to pH 4.5		99			

[a]Average removal efficiencies are reported.
[b]Blanks indicate data not collected.
[c]G/L = 0.19 kg/L (1.6 lb/gal) average.
[d]Hydraulic retention time = 16 hours, sludge age = 32 days.
[e]Contact time = 19 minutes.

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***W. W. Liberick, Jr.** is the EPA Project Officer (see below).*
The complete report, entitled "Logan Wash Field Treatability Studies of Wastewaters from Oil Shale Retorting Processes," (Order No. PB 84-211 143; Cost: $17.50, subject to change) will be available only from:

National Technical Information Service
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