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Secondary lead production in Malaysia

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Abstract

The increase in the number of vehicles and, subsequently, the volume of batteries made by manufacturers in Malaysia have seen a dramatic rise in lead demand over the last five years. Without any lead mines, the only source of lead in Malaysia has been from the recycling of lead/acid batteries. Metal Reclamation (Industries) has commenced the design of a new and advanced secondary lead plant at West Port, Malaysia to meet the increasing demand for lead and the increasingly stringent environmental regulations. The plant is designed to produce up to 75 000 t of lead and lead alloys per year. The plant will also produce, as by-products: polypropylene chips, wallboard-grade gypsum, non-leachable slag for use in construction. A discussion of the process and the products from the new secondary smelter is outlined. © 1998 Elsevier Science S.A. All rights reserved.

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1. Introduction

Metal Reclamation (Industries) (MRISB) has been the only secondary lead producer in Malaysia for the past 25 years and has since become the single largest producer in the ASEAN countries. The company's 99.97% refined lead brand name 'MRISB' is also registered with the London Metal Exchange.

The existing battery-breaking, smelting and refining facility is located in Taman Selayang Baru in Selangor and occupies approximately 1.6 acres of the industrial estate. The overall production capacity of lead alloys is 37 000 t/a.

MRISB's project is to build a large and modern smelter at Pulau Indah, West Port, that will meet future lead alloy demand, meet all of the future environmental regulations, and incorporates all of the best practices from leaders in the lead industry.

2. Malaysian market—lead supply and demand

Malaysia's total lead consumption is 70 000 t/a, and over the last five years, has been growing at about 8% per annum in line with the growth of the local car manufacturing industry and increasing Malaysian vehicle population [1]. Table 1 shows the historical growth in Malaysian lead consumption and MRISB's corresponding lead production.

In 1996, 75% of lead consumed was used in automotive battery manufacture for domestic market and export. About 50% of MRISB's annual lead production is used in the manufacture of low-antimony negative grid alloys and the 1.5 wt.% antimonial alloys for positive grids, straps and poles. At MRISB, secondary bullion from recycled lead/acid batteries is used in antimonial-lead alloy production. Solder drosses are also treated to make bullion for tin/lead alloys.

There is now some interest from local battery makers for MRSIB to make lead–calcium alloys for the manufacture of low-maintenance hybrid batteries, and this will be an important part of the new refinery at Pulau Indah. The production of lead–calcium alloys can be made from refined secondary lead [2].

Current secondary bullion capacity is limited to 12 000 t/a due to a lack of space to install additional furnaces on the existing site. For this reason, and to supply the growing alloy market in Malaysia, MRISB has commenced the design of a new smelter on 12 acres at Pulau Indah in West Port Industrial Estate near Klang. The new smelting furnace will produce up to 75 000 t of lead and lead alloys per annum (see Fig. 1).

3. Secondary lead production at Pulau Indah

3.1. Battery handling

The Pulau Indah Plant is designed to receive batteries still full of acid to stop the current practice of draining acid

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Table 1
Malaysian lead consumption and lead production

Year	Lead consumption (t/a)	MRISB lead production (t/a)
1993	51 000	29 500
1994	53 000	35 000
1995	66 000	36 500
1996	70 000	37 000

Source: ILZSG June 1997 and MRISB.

into the environment before transport. Lead/acid batteries will arrive in lorries and will be unloaded from the side into two 100-t raised collection pits. Container shipments of batteries will be unloaded in the yard by forklift trucks. All of the battery scrap will be moved into the storage bunker using an overhead travelling grab crane or the forklift.

The small number of industrial batteries are handled by forklift and unloaded in the drum-handling section. The batteries are manually uncoupled before being cut into sections. Steel, hard plastics, nickel/cadmium batteries and other materials are removed from the feed to the battery-breaking plant.

3.2. Battery storage bunker

The battery storage area will be contained and have a surface-hardened, acid-proof floor for the collection of the battery acid drained from the stockpile. Acid will be collected in a sump for removal of sludges and then filtered before storage in a 100-m^3 tank. Spent electrolyte will be sold for recycling but can be sent to the effluent treatment plant for removal of the dissolved metals.

3.3. Battery crushing plant

The battery breaker (refer to Fig. 2) is made of stainless steel and will crush batteries with a hammer mill and separate them into individual components. The acid mists generated from the crusher will be collected and vented to a scrubber.

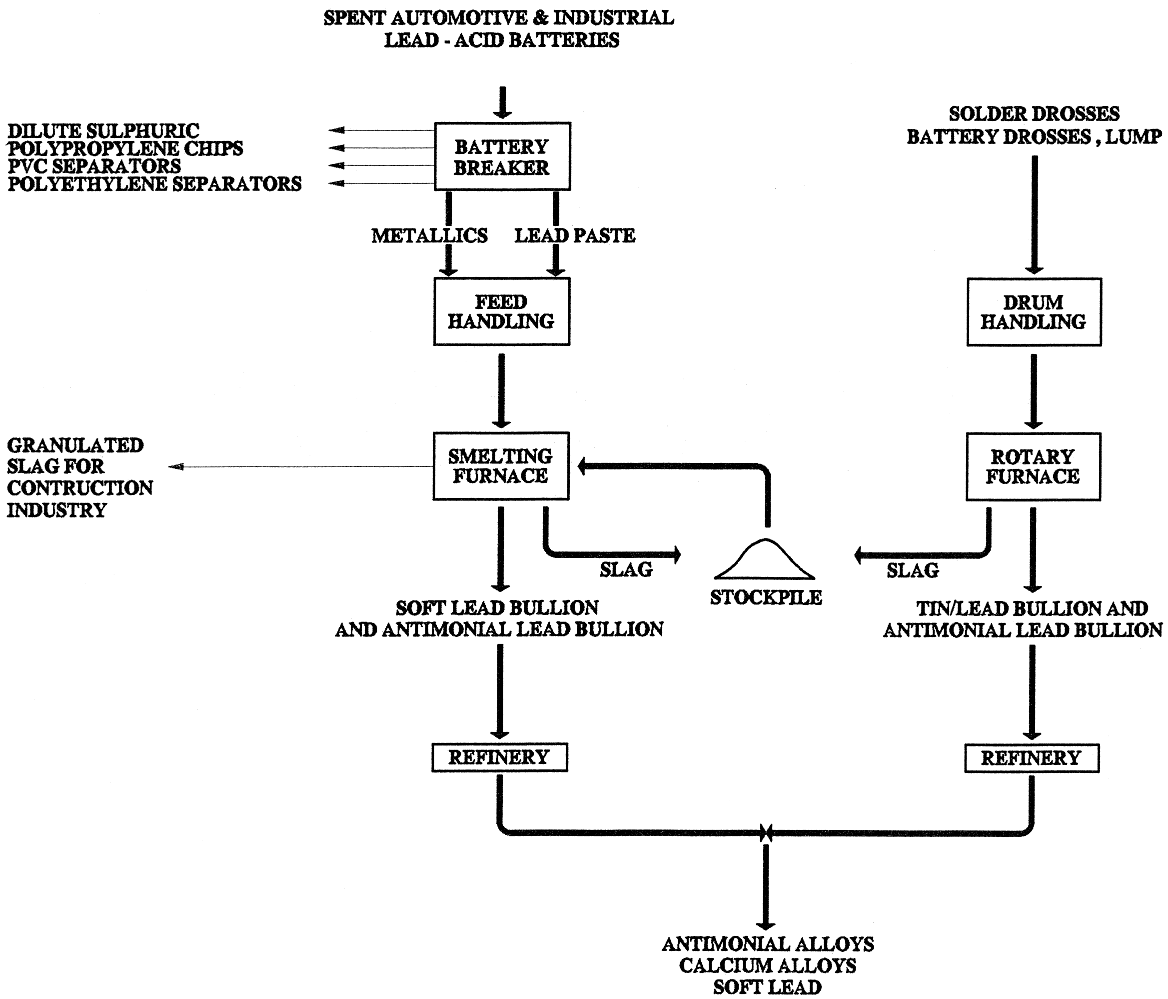

Fig. 1. Secondary lead flow chart.

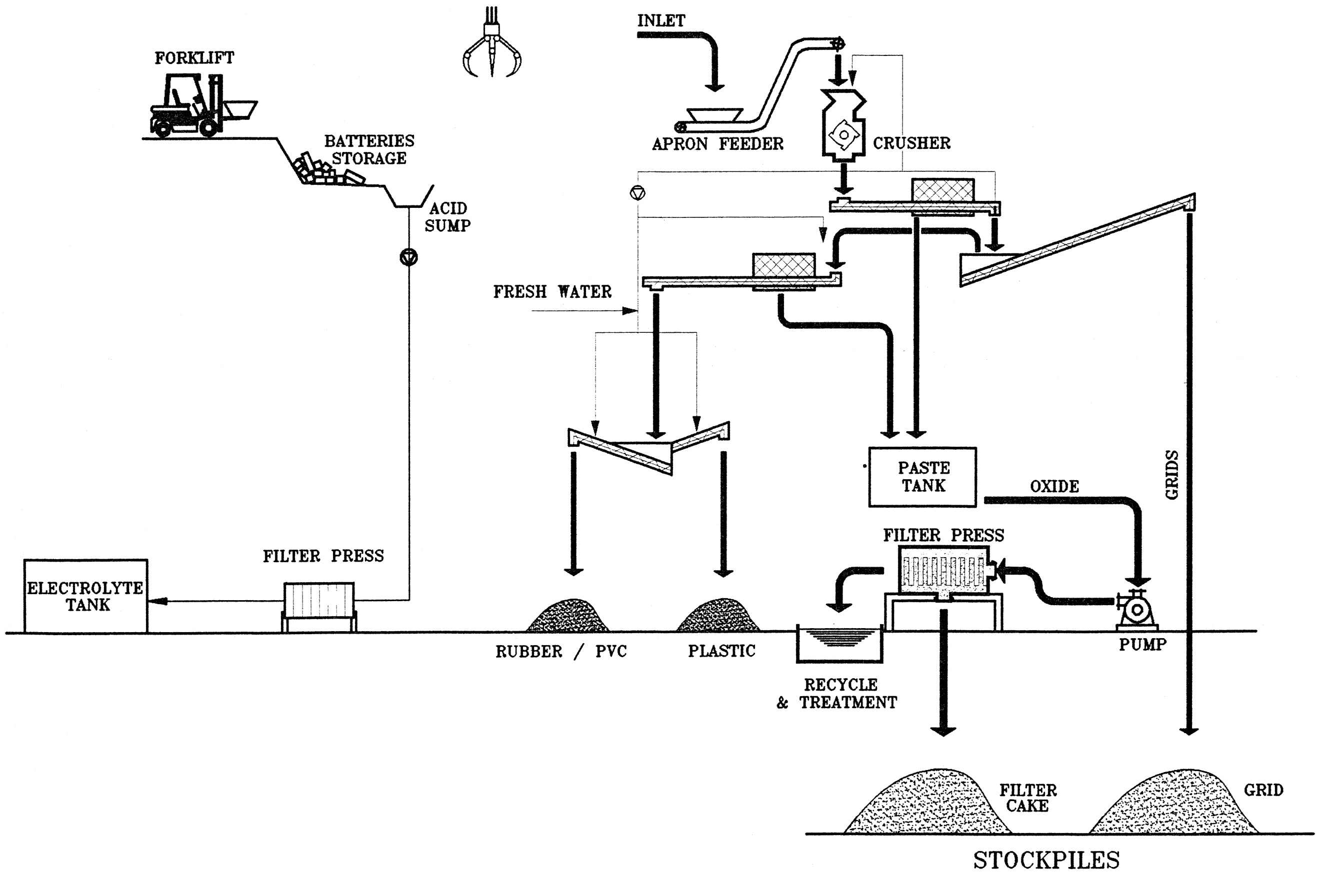

Fig. 2. Flowchart for battery breaker.

The crushed scrap is screened to remove the paste fraction and the oversized grid metal and plastics are screwed to a gravity separator where the heavy grid metal sinks, and is collected. The plastics are then washed and further separated into polypropylene and the heavier separator fraction.

The polypropylene chips are sent to a washing plant for final rinsing with fresh water and draining. The polypropylene will then be bagged and sold to plastic recyclers. The polyethylene is separated from the PVC for use as fuel in the rotary furnace.

The lead paste from the washing and screening process is collected, and the lead metal fines removed in an upflow elutriator. The paste is then collected in a stirred tank for pumping to a filter press in the material handling plant.

Waste water filtrate from the paste filtering process is collected and recycled back to the plant. Any excess waste water is sent to the effluent treatment plant.

3.4. Materials handling plant

Paste filter cake and grid metal will be stockpiled on the floor of the enclosed building; Coke reductant, fluxes, and mixed fume dust and drosses are held in storage bays. Purchased battery sludge will be unloaded and collected in a pit. The slurry will be pumped to the battery breaker plant. There will be 2500 t storage capacity for paste and 1600 t for grid. The stockpiling of material allows some oxidizing, and lowers the moisture content of the paste further.

All of the materials will be fed by an overhead grab into hoppers for feeding into the smelting furnace. The paste and grid hoppers will have a 25-t capacity, which is the size of one batch. All of the materials will be continuously weighed over a feeder belt during the 2- to 3-h batch, and the rate of feed will be computer-controlled according to operator setpoints.

3.5. Paste smelting

The smelting furnace (see Fig. 3) utilizes submerged lance technology originally developed by CSIRO in Australia and installed in lead smelters in Australia [3], UK [4], Germany [5] and Namibia [5]. It comprises a single, 8-m high, vertical furnace with a diameter of 2 m and is refractory-lined. To commence smelting, the lance is lowered into the molten bath and splash-coated with a protective slag layer. The highly turbulent bath conditions allow high temperatures and improve energy efficiency to make silica-rich non-leachable slags under controlled conditions.

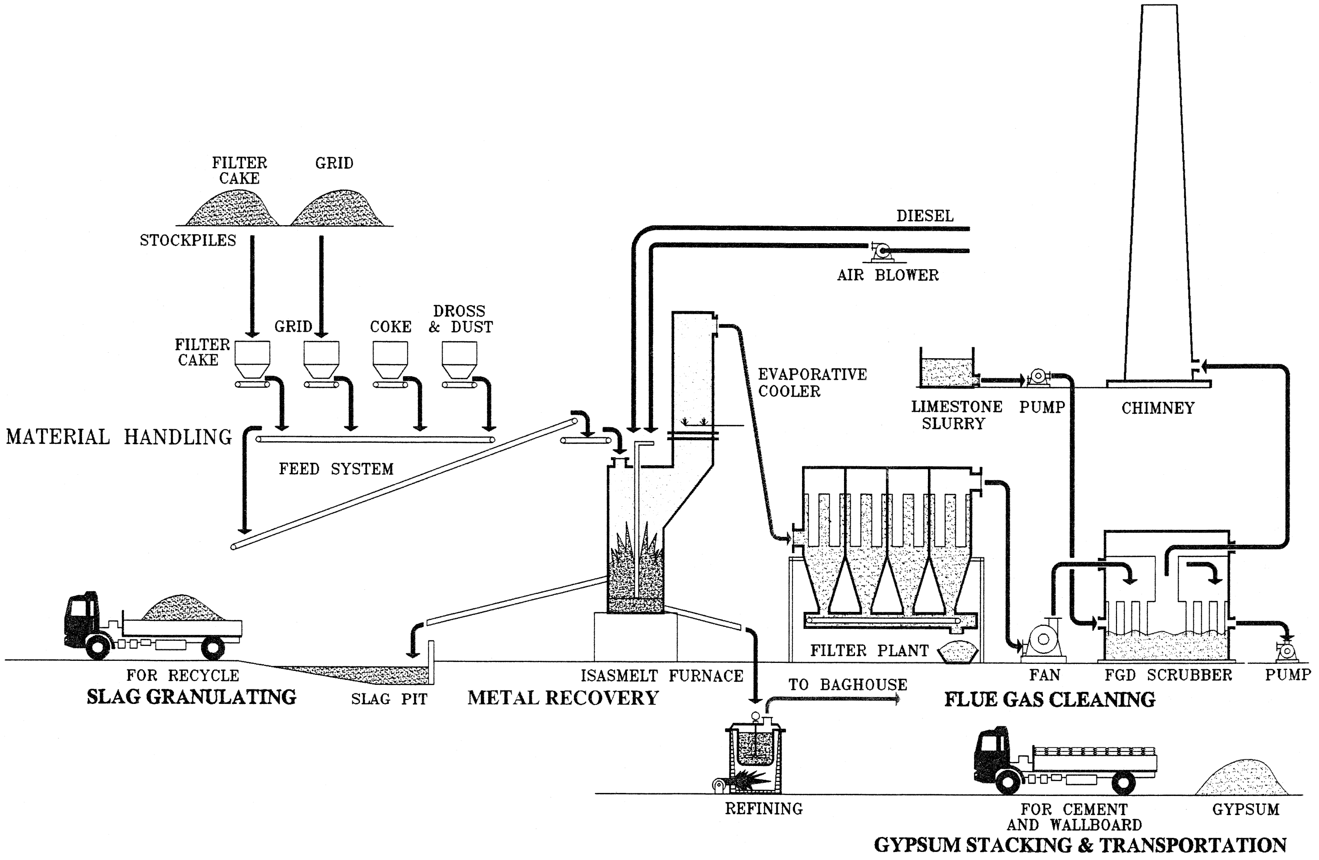

Fig. 3. Flow chart for smelting process.

Coke is added with the paste to reduce the lead slag to make a soft lead. A small amount of high lead–antimony slag will be accumulated before being tapped and stockpiled for future slag recovery.

Gas emitted from the furnace will contain lead fume and sulfur dioxide produced by the reactions of lead sulfates in the paste. These are both removed in the gas handling system. The lance port, feed port, slag and lead tapholes will all be vented to a separate hygiene baghouse for added environmental protection.

The slag stockpiled from the paste smelting cycle will be recycled back to the furnace in campaigns of up to two weeks. The slag is fed at a rate of 4 t/h with small amounts of iron and limestone fluxes added to give slag consistency. More coal is added to reduce the slag down to lead levels below 2 wt.%. A bullion containing 20 wt.% antimony is produced and is tapped intermittently. The final slag will be tapped and quenched in a high-pressure water jet to produce material particles of 2–3 mm. It has been demonstrated that the heavy metals in the slag will be non-soluble and will pass a leach test. Local cement and concrete manufacturers have shown an interest in this material (shown in Table 2).

Table 2
Smelting furnace refined slag—expected analysis

Parameter	Concentration (wt.%)
FeO	45
SiO_2	25
CaO	18
MgO	6
Al_2O_3	4
Pb, Sb, Sn	< 2

3.6. Solder dross and battery dross smelting

The existing rotary furnace from Selayang will be relocated to Pulau Indah for the smelting of solder drosses and battery drosses, as well as for the melting of grid metal. The antimonial and tin bullion from the furnace will be cast into blocks and will be used for blending and production of tin and antimonial alloys. The small amount of slag skim from this process will be broken up and recycled with the other slag to be made into iron–silica–lime slag in the smelting furnace.

3.7. Refining

The lead refinery will be a traditional kettle refinery with seven kettles to refine the furnace bullion, and any additional purchased secondary bullion. The soft lead made when smelting paste in the smelting furnace is tapped directly by launder to either of two 50-t drossing kettles. The skim is dried, collected and recycled to the furnace.

The soft bullion from the smelting furnace will have a quality of 0.1 wt.% antimony and can be pumped directly to alloying kettles, if required, to make calcium alloys or soft lead alloys.

Hard lead from the smelting of grid metal, drosses and the high antimony recycled slag is cast into 1- to 2-t blocks. These blocks will be added to the drossing kettle to make the desired battery alloys while also acting to cool the hot tapped lead.

There are three alloy lines in the refinery. One line of two 50-t pots and a casting machine is used for finishing of antimonial alloys, another line of two 50-t kettles and casting machine is used for soft lead alloys, while a third line with a 30-t kettle and casting machine is used for production of calcium alloys. The separate product lines prevents cross-contamination from lead of previous casts.

4. Environmental controls

4.1. Effluent treatment plant

Electrolyte from the lead/acid batteries and waste water from the process area will be treated using chemicals and flocculant. Metals such as lead, cadmium, copper, iron and tin are all collected in the filtered sludge and will be recycled to the furnace for metal recovery. The maximum allowable effluent discharge limits are shown in Table 3.

4.2. Gas cleaning plant

The gas from the smelting furnace is cooled using atomising water sprays before entering the baghouse filter unit that has a capacity of 25000 N m^3 h^{-1}. The baghouse uses high performance bags for removal of lead fume in the pulse-jet baghouse and this will be collected for recycling back to the furnace.

The hygiene baghouse will ventilate all ports from the smelting furnace and will have a capacity of 54000 N m^3 h^{-1}. The refinery kettles are all ventilated and exhausted through a dust collector with 50000 m^3 h^{-1} capacity before exiting from the refinery stack.

Table 3
Maximum allowable effluent discharge limits

Parameter	Unit	Limit
pH		5.5–9.0
BOD in 5 days at 20°C	mg/l	50
COD	mg/l	100
Suspended solids	mg/l	100
Lead	mg/l	0.5
Cadmium	mg/l	0.02
Zinc	mg/l	4.0
Tin	mg/l	1.0
Copper	mg/l	1.0
Nickel	mg/l	1.0

Table 4
Maximum allowable stack discharge limits (mg N m^{-3})

Parameter	Limit
Lead	25
Cadmium	15
Zinc	100
Arsenic	25
Copper	100
Mercury	10
Sum of any 5 metals	40
Particulates	200

The maximum allowable stack discharge limits are shown in Table 4.

4.3. Flue gas desulfurizing

Sulfur dioxide from the smelting of paste is removed in the FGD to meet the Malaysian Air Quality Guidelines (shown in Table 5). An analyzer will be installed to monitor the sulfur dioxide emissions and, to meet the standard, the FGD is designed to remove sulfur dioxide emissions up to 95%.

Sulfur dioxide is removed from the FGD reactor by the injection of the process gas into a limestone slurry to make calcium sulfate or gypsum. The advantages of this system are the very low plant downtime compared with conventional spray tower designs and the high-quality grade gypsum that is made from the plant.

All of the gypsum will be collected and will be pumped to a filtering plant where it will be dewatered, dried and then trucked to customers to make cement and wallboard.

4.4. Solid wastes

All steel, pallets and other wastes will be consumed in the furnaces for recovery of the iron and for fuel. The only waste from the entire site is the small amount of non-recyclable PVC separators that are safely landfilled.

4.5. Lead controls

A number of best practices will be implemented at the new site, which will prevent lead migration from the Pulau

Table 5
Recommended Malaysian air quality (ambient air) guidelines (μg N m^{-3})

Parameter	Guideline	Time frame
Lead	1.5	3 months
Particulates	260	24 h
	90	1 yr
SO_2	500	10 min
	350	1 h
	105	24 h

Indah site, and control employee lead in blood levels. The Malaysian legislation for lead in blood is expected to be reduced from the current 80 $\mu g\ dl^{-1}$.

A lorry wash will be installed for the washing of lorries before leaving the site. All floors of the process area will slope towards drains for collection of process water into sumps. Sludges will be recycled to the process, while excess waste water will be directed to the effluent treatment plant. Rain falling on specific process areas will also be collected in tanks for filtering and analysis before safely discharging. All discharged water will be sampled to confirm that it meets the effluent limits.

All production personnel will be given clean work clothes on a daily basis. Their dirty clothes at the end of each shift will be laundered on site, and all personnel will be required to shower before leaving work. To enter the production area, all personnel including visitors must pass through the change house. The change house has a ‘clean’ side where personnel change out of their clothing, and a ‘dirty’ side where they change into their work clothes and pick up their protective equipment.

To protect workers, all personnel will be required to wear respiratory protection and will undergo lead-protection training as part of their induction. All personnel will undergo medical screening and frequent blood–lead testing. The eating area will be in the change house building, away from the process area. All personnel will be required to wash and remove boots and lead-stained clothing before entering the eating room. All process offices and the control room will be pressurized with clean, fresh air, and smoking will not be permitted in the process areas. Table 5 shows some of the current requirements of the Malaysian Department of Occupational Safety and Health’s Lead Regulations.

4.6. Final remarks

It is MRISB’s ultimate aim to achieve environmental recognition at Pulau Indah by thorough plant design, and then by introduction of Total Quality and Environmental Management systems in order to meet ISO 14000. The intention is to be the best lead-recycling plant in Southeast Asia, if not Asia.

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