Demonstrated Operation of Chlorine Contained Waste Incineration System For Transuranic Contaminated Wastes - 9181

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ABSTRACT

Plutonium-contaminated solid wastes including combustible, incombustible and chlorine contained waste have been generated during Mixed Oxide,(MOX) fuel fabrication by Japan Atomic Energy Agency (JAEA). Incinerations of chlorinated wastes cause the problems related to corrosion of the equipments and dust loading in the vent exhaust system. The JAEA has designed and manufactured a new type incineration system for chlorine contained wastes and combustible wastes based on past experience gained by the operation of the Plutonium contaminated Waste Treatment Facility (PWTF) to solve similar problems. Moreover, equipments should be air-tight to prevent t contamination in work environment. The incineration system has been operating since June 2002. Plutonium contaminated solid wastes treated so far amount to 230m^3 (36.7ton). The volume reduction factor was approximately 45 (weight reduction factor is approximately 12). The incineration system has successfully operated without contamination of the work environment maintaining its air-tightness. As a result of long term operation, no significant corrosion damage of the system could be observed.

INTRODUCTION

Plutonium-contaminated solid wastes have been generated during MOX fuel fabrication process by the Japan Atomic Energy Agency (JAEA). The generated plutonium contaminated solid wastes can be classified into combustibles, incombustibles and chlorinated wastes. Typical combustibles are cleaning fabrics, working clothes, polyethylene bottles, and vinyl acetate sheets. Incombustibles are dismantled glove boxes, equipments and filters. Chlorinated wastes are polyvinyl chloride (PVC) bags, chloroprene rubber gloves and latex gloves. These wastes are packaged in 20ℓ carton box (as shown in Fig.I). Six carton boxes are put into 200ℓ drum. Large wastes are put directly into 1.7m^3 cubic containers. All of the plutonium contaminated wastes are covered with PVC bag because the wastes are taken from the glove box by means of bag-out process. Chlorine contained solid wastes such as PVC bags and chloroprene rubber gloves have been steadily generated during operation of the MOX fuel facilities, because MOX fuel fabrication equipments are installed in glove boxes. Therefore the percentage of chlorinated wastes in the MOX fuel facilities is higher than other nuclear cycle facilities. Due to the limited storage space, development of volume reduction technology for chlorinated wastes is necessary.

In 1987, JAEA built the Plutonium contaminated Waste Treatment Facility (PWTF) and put into hot operation(1). This facility comprises a sorting and pretreatment line, conventional incinerator and cyclone type incinerator.

The conventional incinerator was used for combustible waste. However PVC bag wrapping combustible wastes should be removed in the pretreatment line because of corrosion of the equipments and dust loading in the exhaust system. Chlorinated wastes were incinerated by the cyclone type incinerator. Chlorinated wastes were prepared by size reduction into 5mm x 5mm by shredding units before feeding the cyclone type incinerator to accelerate the burning reaction. Throughput of the cyclone type incinerator is quite low due to the troublesome pretreatment.

JAEA had designed and manufactured a new type incineration system for the chlorinated and combustible wastes based on past experience of the PWTF. This paper presents a brief overview of the new type incinerator and demonstrated operation results.

Fig.1. Waste package for plutonium contaminated wastes (20ℓ carton box)

PROCESS DESCRIPTION

Fig.II shows process flow of the incineration system. The system consists of waste feeder, water-cooling jacket type incinerator, primary ceramic filter, exhaust cooler, secondary ceramic filter, HEPA filter, alkali scrubber and other exhaust gas purifications units. Equipment is an air-tight structure to prevent contamination in work environment. Therefore, wastes feed, ash extraction and equipment maintenance were carried out through glove boxes.

Corrosion resistance and cost were the primary criteria used in selection of the materials for the incineration system. Main equipments are manufactured from nickel alloy or ceramic coated stainless steel to prevent acid corrosion. Ceramic coated stainless steel was utilized where possible if the highest operating temperature anticipated in the equipment was within the recommended operating range of ceramic coating (180ºC). Nickel alloy was selected for where the equipment was operated above the ceramic coating design temperature.

Furthermore, the equipment is maintained at the temperature above acid dew point (155 ºC) to avoid internal condensation.

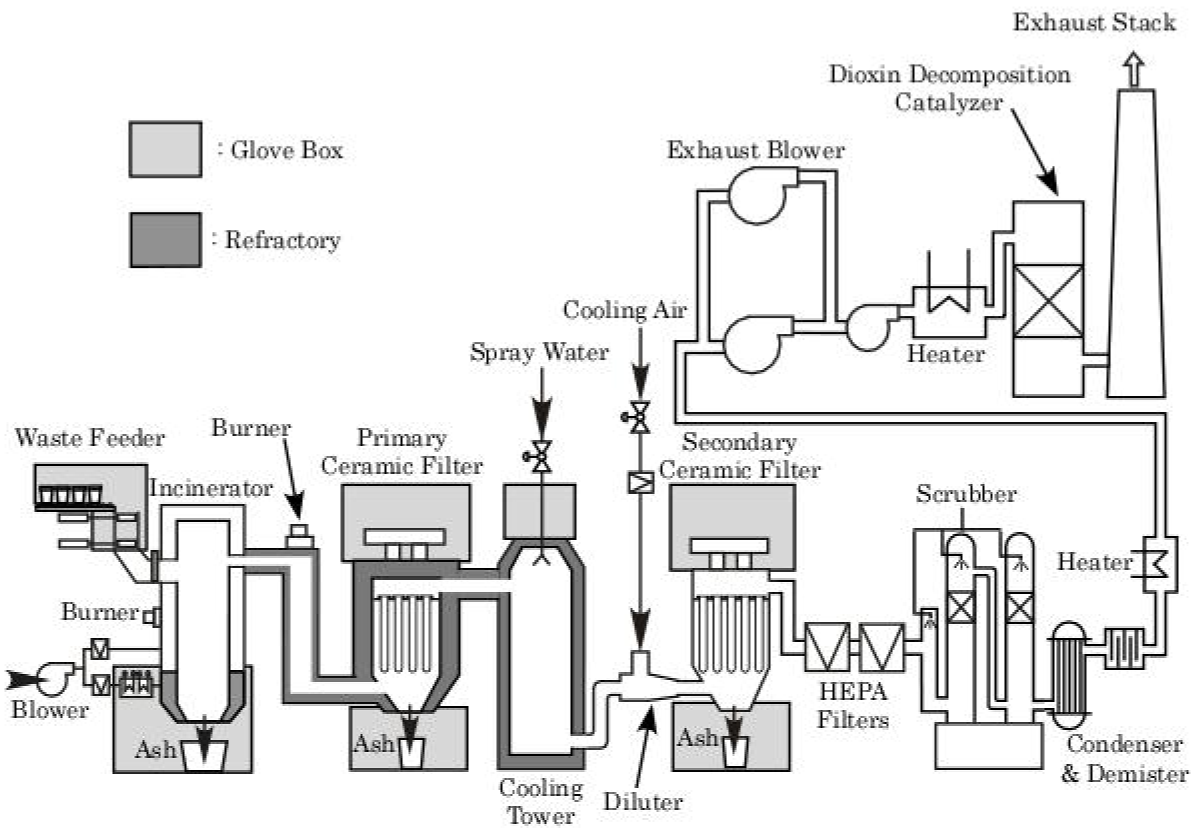

Fig.1I. Schematic flow diagram of incineration system

Waste Feeder

The solid waste packaged drums are accepted from waste storage facilities at the receiving area of the PWTF. At the waste pretreatment process step, the waste drum is opened and the waste packages are taken out from the drum.. The surface contamination of the package, weight, dose rate and absence of metal particles is checked. The waste packages are loaded into the glove box via an air lock. The waste packages are individually fed into the incinerator through two slide gates without any pretreatment. The two gates create a barrier between the glove box atmosphere and the incinerator.

Incinerator

Fig.III is a schematic illustration of water cooling jacket incinerator. The incinerator is bicylindrical structured, and cooling water circulate through the cylinders to prevent local temperature hot spots. Combustion air is supplied at high velocity from air nozzles arranged all over the inner wall of the incinerator to accelerate burning the chlorinated wastes. The waste is ignited by the primary burner. Throughput of the incinerator is 10kg/h.

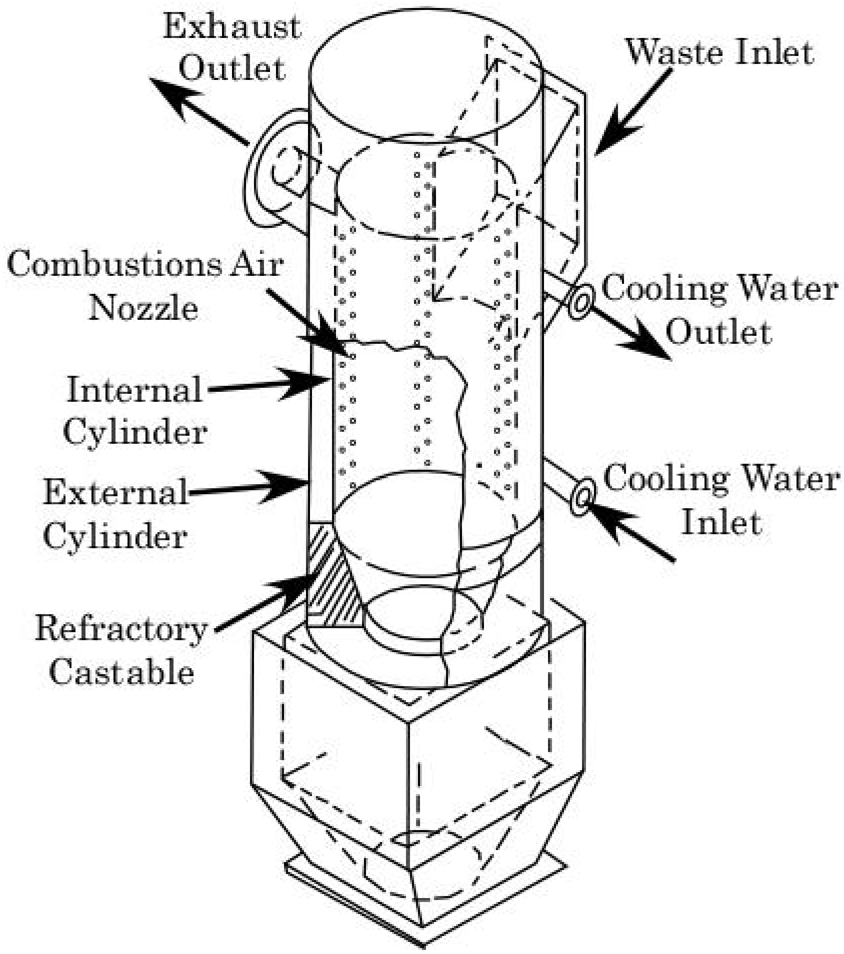

Fig.III. Schematic illustration of water cooling jacket incinerator

Primary Ceramic Filter

Exhaust gas temperature is raised up over 550 ºC at the primary ceramic filter chamber in order to enhance the secondary combustion. Incinerator fly ash is trapped by ceramic filter elements. The collected ash is blown off form the surface of filter media by mean of pulsed jets of compressed air.

Exhaust Gas Cooler

The gas cooler consists of spray cooling tower and air dilutor. The quench cools the flue gas exiting the first ceramic filter at gas exhaust temperature above 600ºC to below maximum operating temperature of

HEPA filter (250 ºC) by mean of water atomization and air dilution.

Secondary Ceramic Filter

When the flue gas stream containing volatile chloride ($PbCl_2$ and $ZnCl_2$) is cooled, the volatile chlorides condense into particles. The condensed particles are trapped by ceramic filter elements to prevent clogging of the HEPA filters. The ceramic filter elements are coated with silica powder. The collected chloride is blown off form the surface of filter media with pre-coated silica powder by mean of pulsed jets of compressed air.

Exhaust Gas Purification

After having passed the secondary ceramic filter, the gasses enter the HEPA filters, consisting of two inline units. The outlet temperature is 200 °C. The alkali scrubber consists of a quench tower for the cooling down of gasses below 50 ºC, a counter current scrubbing tower with caustic liquid for removal of HCl and SO_2, condenser, and demister. The flue gases are heated above 30 ºC in order to decrease the relative humidity and to avoid condensation. Two extraction blowers in parallel ensure the evacuation of flue gasses into the atmosphere. One blower is stand-by. The dioxin is decomposed at 300ºC by a catalyser.

The exhaust gas treatment system has features in that radioactive liquid waste is not generated because the alkali scrubber is installed after the HEPA filters.

OPERATIONAL RESULTS

Table I shows the amounts of treated waste per fiscal year, the collected ashes, the weight reduction and volume reduction factors. The plant currently has about 5000 operational hours and has treated so far amount to 34.6ton (216m^3). The breakdown is; PVC 61%, rubber 21%, paper 6%, plastic 12% (wt.%). The volume reduction factor was approximately 45, and weight reduction factor is approximately 12 (volume or weight reduction factor defined as the volume or weight of total waste fed into the incinerator divided by the volume or weight of total ash).

Table II shows the typical operational conditions, and Fig.IV shows temperature profiles. Exhaust gas and cooling water temperature of incinerator raised higher when high calorific plastics was incinerated. However the temperature of HEPA filter varied only slightly because the exhaust gas cooler had enough excess capacity. Operating pressure was maintained sub atmospheric as shown in Fig.V. Ignition loss of incineration ash was less than 10 wt.%. Fig.VI shows differential pressure profile of the ceramic filters. The differential pressure increased as increasing amount of trapped fly ash and the build up of volatile chlorides. The differential pressure returned to theinitial pressure following the backwashing of the ceramic filters. HEPA filter life was more than 2000 hours without clogging.

No detectable radiation was found in the liquid waste generated from the alkali scrubber.

The atmosphere in the work environment was monitored continuously with dust sampling units. No significant atmospheric contamination was detected. Surface contamination of work area and the process equipment were checked by mean of daily and weekly smear testing. The result's indicated, that no surface contamination was detected. The incineration system had been maintained its air-tightness.

Corrosion wastage of the incineration system was measured by mean of an ultrasonic thickness gauge. No significant corrosion wastage was observed following long term operation of the facility.

Table I. Operational results of the incineration system

Fiscal year	2002	2003	2004	2005	2006	2007*	2008	Total
Chlorinate waste (tons)	3.6	9.3	5.6	2.2	2.8	-	5.9	29.4
Combustible waste (tons)	-	-	-	3.9	1.0	-	2.4	7.3
Total weight of waste (tons)	3.6	9.3	5.6	6.1	3.8	-	8.3	36.7
Total volume of waste (m^3)	24.3	55.7	33.2	41.9	23.8	-	51.1	230.0
Collected incinerator ash (tons)	0.24	0.64	0.36	0.32	0.20	-	0.57	2.33
Collected fly ash (tons)	0.07	0.19	0.11	0.08	0.04	-	0.09	0.58
Total collected ash weight (tons)	0.31	0.83	0.47	0.46	0.24	-	0.66	2.97
Total collected ash volume (m^3)	0.63	1.34	0.73	0.77	0.47	-	1.13	5.07
Weight reduction factor	11.6	11.2	11.9	13.3	15.8	-	12.5	12.4
Volume reduction factor	38.6	41.5	45.6	54.5	50.9	-	45.3	45.4

* It did not operate because of the government license renewal.

Table II. Operational condition of the incineration system

Waste Material		PVC, Rubber	Paper, Fabric	Plastic
Feed rate (kg/h)		9.5	6.0	4.0
Temperature (ºC)	Incinerator exhaust	200 ~ 350	200 ~ 300	200 ~ 500
	Cooling water	30 ~ 50	30 ~ 40	30 ~ 60
	Primary ceramic filter	550 ~ 650	550 ~ 650	550 ~ 650
	HEPA filter	200	200	200
Operating pressure (Pa)		-3000 ~ -4700	-3000 ~ -4700	-3000 ~ -4700
Flow rate of exhaust gas (Nm^3/h)		770 ~ 890	770 ~ 890	770 ~ 890
Ignition loss (wt %)		<10	<2	<1

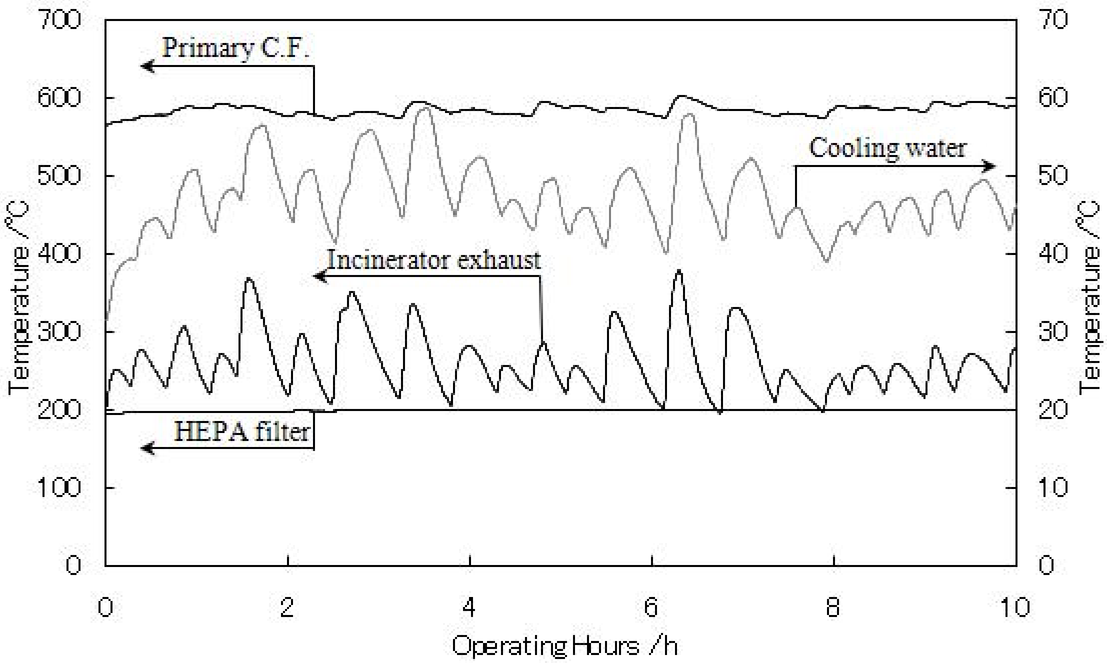

Fig.IV. Temperature profiles of the incinerator

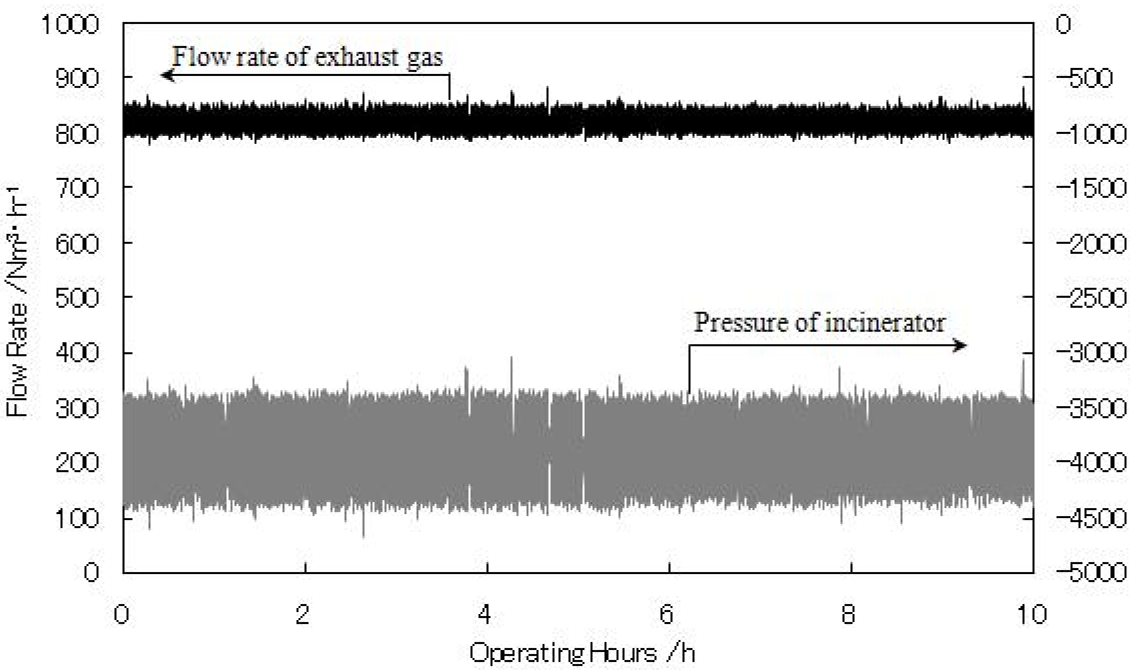

Fig.V. Pressure and flow rate profiles of the incinerator

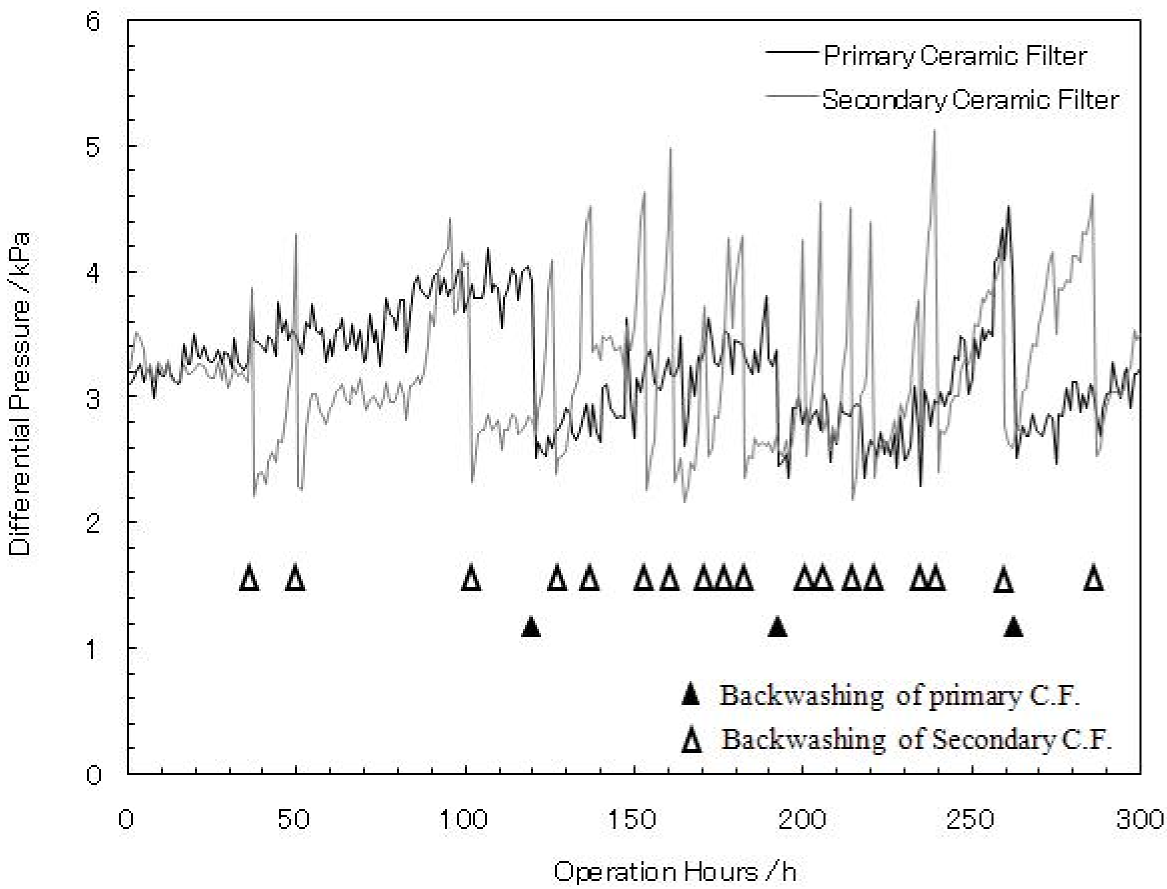

Fig.VI. Differential pressure of ceramic filters

CONCLUSION

Demonstrated operation of the chlorinated waste incineration system has been performed for treatment of plutonium contaminated wastes generated from MOX fuel fabrication facilities. Plutonium contaminated solid wastes treated so far amount to 36.7ton (230m^3). The volume reduction factor was approximately 45 (weight reduction factor is approximately 12). Ignition loss of incineration ash was less than 10 wt. %. The fly ashes and the volatile chlorides in the exhaust gas were trapped by filtration followed by backwashing of ceramic filters. The incineration system operated without contamination of the work environment by maintaining its air-tightness. No significant corrosion wastage was observed during the long term operation.

REFERENCE

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