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Success Story: Operation Excellence and Maintenance Strategy for Geothermal Development in Indonesia

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ABSTRACT

Indonesia has abundant resources of geothermal in the world since it is located in ring of fire. According to Indonesia Ministry of Energy and Mineral Resources, it has total potential of 27 GWe which is spread accros 252 location such as Java, Sulawesi, Sumatera, Bali and Nusa Tenggara. Reconnaissance survey was undertaken in 1960s and identified that it has potensial high-temperature system criteria of discharge termal fluid (Hochstein & Sudarman, 2008).

Over 35 years of developing geothermal energy in Indonesia, PT. Pertamina Geothermal Energy, a subsidiary company of PT. Pertamina (also known as PGE), encounters several eras of technology. Starting development by 1983, the first 30 MW geothermal power plant (Unit 1) was commercially operated in Kamojang Field, West Java and followed by Unit 2 & Unit 3 which were started 2x55 MW electricity five years later. The steam for those power plants was supplied from 38 wells using approximately 13km length of pipeline and the monitoring program held at the moment were performed manually using analog instruments. By 1993-2003, monitoring system gradually transformed from analog to digital technology and in 2005, maintenance program was initially implemented using risk based inspection. By 2008, Additional 60 MW Unit 4 was energized and increased field production to 200 MW. At the moment, maintenance program was started using Maintenance Performance-Based Maintenance Decision Support System (MDSS) and integrated with supply chain and logistic management. Sever years after that, Fifth geothermal power plant (Unit 5) in Kamojang field was generated In 2015 and at the same year, Reliability Centered Maintenance (RCM) based Maintenance Program for both steam gathering system and power plant was lauched for both steam gathering system and power generation facilities to ensure that the system continue to do as the requirement in their present operating context. The latest technology for maintenance program was held by the early 2018 where Android based Seamless Asset Management System (SAMS) are applied to reduce paperbased and time consuming monitoring system.

Not only in Kamojang, Geothermal were also utilized in other field in Indonesia. They are Sibayak Field, North Sumatera that generate 12 MW; Ulubelu Field, Lampung that produce 4x55 MW; Lahendong Field, North Sulawesi that has 6 units of 20 MW power plant respectively and also Karaha Field, West Java that energize 30 MW. So in total, PGE has develop 617 MWe geothermal energy and these units has an important role in developing operation and maintenance best practice in geothermal industry in Indonesia.

1. INTRODUCTION

Geothermal energy was not new in Indonesia since it has been developed over 35 years by PGE. Developing renewable enegy in Indonesia, PGE has a vision statement to be world class geothermal energy company by 2025. It is believed that world class company is determined by its capacity, process and sales. So to be world class company, PGE needs to improve its process in operation and maintenance.

First power plant generated in Indonesia was in Kamojang Field and far before first power plant was operated in 1982, 500 kW small-scale Geothermal Monoblock was operated by 1978. Currently, the geothermal energy resources in Indonesia has been exploitated in Kamojang Field (234 MW), Ulubelu Field (220MW), Lahendong Field (120 MW), Karaha Field (30 MW) and Sibayak Field (12 MW) and PGE has owned-operated 7 over 33 geothermal power plants (GPP) in Indonesia. It gives PGE the opportunities and experience to development operation and maintenance excellence way.

From 1982 until now, the way PGE monitor and maintain its operational are devided into 3 phase : analog phase, digital phase and integrated smart machine phase

2. ANALOG PHASE (1983 – 1992)

By 1983, GPP Unit 1 is commercially operated by PT. Indonesia Power (IP) in Kamojang. This first geothermal steam turbine generate 30 MW electricity which steams are are supplied by PGE using 3.7 km length pipe line (PL-401).

Five years after that, Unit 2&3 were started commercially by IP. They generate 2x55 Mwe so in total 140 MW electricity have been developed in Kamojang Field. Steams for these 2 units are feeded by pipe line PL-402, PL-403 and PL-404 which the length are 2.5 km; 4.7 km and 4.8 km respectively. Steam quantity and quality that PGE gives to customers are legally explained in steam purchase agreement. Thus for monitoring several parameter, measuring instruments were installed in each well head and also in main header such as flow, temperatures and pressures. At the moment, operators need to go to cluster day by day, to check those paratemeters manually in order to get data of fluids. It is also needed to maintain the quality and quantity of fluid that PGE gives to customers. Maintenance program for steam facilities was perfomed by common practise suck as visual checking in pipe line and some corective action such as valve recondition and pipe replacement.

Figure 1: 1987 view of the finished scheme, Powerhouse Kamojang I

3. DIGITAL PHASE (1993 – 2007)

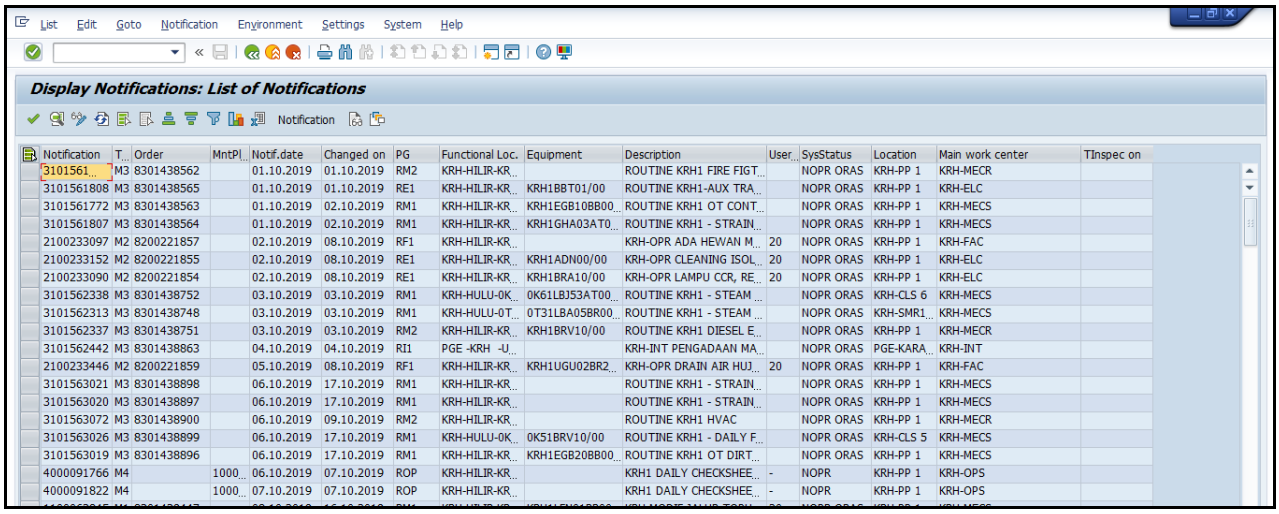
PGE started to switch previous manual monitoring instrument with digital monitoring equipment at 1993. Annubar flow meter was install in PL-401, PL-402, PL-403 and PL-404 order to gives averaging better accuracy in reading steam flow meter delivered to customers. Eventhough several monitoring equipment have been changed from analog to digital, operator still need to go to the cluster and header to collect the data by themselves.

By 2000, control valve and digital annubar flow meter were installed on several big wells only in Kamjang Field. Those wells are KMJ-18, KMJ-27, KMJ-36 and KMJ-41 that deliver steams for Unit 1, 2 and 3. Three years after that, dedicated control room was build in Kamojang Head Office so that operators can monitor the steam flow from big screen. They are also able to open and close the valve remotely from the control room using Programable Logic Control (PLC) System. This method can reduce physical hazard to operators.

Monitoring above ground steam pipe facilities by 2005 is upgraded using Risk Based Inpection (RBI). Using this methode, pipe, vessel, and valve are assessed based on their consequences and probabilities of failure in operational and financial in order to find the proper inpection program for those facilities.

4. INTEGRATED SMART MACHINE (2008 – Present)

Unit 4, the first GPP owned by PGE, was commercially operated in 2008. It generates 60 Mwe full capacity which is feeded by 6.1 km-length pipe line (PL-405). There are more than 3500 equipments installed in both GPP and steam gathering system. Realizing that a lot of equipments need to be well maintained, PGE starts to implement Maintenance Performance-Based Maintenance Decision Support System (MDSS) as innitial integrated smart machine that help in monitoring all of the equipments in GPP and steam gathering system. Firts off all, these equipments are registered in MySAP. After that, maintenance schedule of each equipment, based on manufacture recomendation, are also uploaded in MySAP. Using this Computerized Maintenance Management (CMM) System everyday, the system will generate notification and operator will be able to notice which equipment need to be monitor. Figure 2 shows list of notification for daily routine maintenance activity which is autogenerated based on maintenance programs that have been uploaded by the system



Notification	T..	Order	MntPl..	Notif.date	Changed on	PG	Functional Loc.	Equipment	Description	User..	SysStatus	Location	Main work center	TInspec on
3101561...	M3	8301438562		01.10.2019	01.10.2019	RM2	KRH-HILIR-KR...		ROUTINE KRH1 FIRE FIGT...		NOPR ORAS	KRH-PP 1	KRH-MECR	
3101561808	M3	8301438565		01.10.2019	01.10.2019	RE1	KRH-HILIR-KR...	KRH1BBT01/00	ROUTINE KRH1-AUX TRA...		NOPR ORAS	KRH-PP 1	KRH-ELC	
3101561772	M3	8301438563		01.10.2019	02.10.2019	RM1	KRH-HILIR-KR...	KRH1EGB10BB00...	ROUTINE KRH1 OT CONT...		NOPR ORAS	KRH-PP 1	KRH-MECS	
3101561807	M3	8301438564		01.10.2019	02.10.2019	RM1	KRH-HILIR-KR...	KRH1GHA03AT0...	ROUTINE KRH1 - STRAIN...		NOPR ORAS	KRH-PP 1	KRH-MECS	
2100233097	M2	8200221857		02.10.2019	08.10.2019	RF1	KRH-HILIR-KR...		KRH-OPR ADA HEWAN M...	20	NOPR ORAS	KRH-PP 1	KRH-FAC	
2100233152	M2	8200221855		02.10.2019	08.10.2019	RE1	KRH-HILIR-KR...	KRH1ADN00/00	KRH-OPR CLEANING ISOL...	20	NOPR ORAS	KRH-PP 1	KRH-ELC	
2100233090	M2	8200221854		02.10.2019	08.10.2019	RE1	KRH-HILIR-KR...	KRH1BRA10/00	KRH-OPR LAMPU CCR, RE...	20	NOPR ORAS	KRH-PP 1	KRH-ELC	
3101562338	M3	8301438752		03.10.2019	03.10.2019	RM1	KRH-HULU-0K...	0K61LBJ53AT00...	ROUTINE KRH1 - STEAM ...		NOPR ORAS	KRH-CLS 6	KRH-MECS	
3101562313	M3	8301438748		03.10.2019	03.10.2019	RM1	KRH-HULU-0T...	0T31LBA05BR00...	ROUTINE KRH1 - STEAM ...		NOPR ORAS	KRH-SMR1...	KRH-MECS	
3101562337	M3	8301438751		03.10.2019	03.10.2019	RM2	KRH-HILIR-KR...	KRH1BRV10/00	ROUTINE KRH1 DIESEL E...		NOPR ORAS	KRH-PP 1	KRH-MECR	
3101562442	M3	8301438863		04.10.2019	04.10.2019	RI1	PGE -KRH -U...		KRH-INT PENGADAAN MA...		NOPR ORAS	PGE-KARA...	KRH-INT	
2100233446	M2	8200221859		05.10.2019	08.10.2019	RF1	KRH-HILIR-KR...	KRH1UGU02BR2...	KRH-OPR DRAIN AIR HUJ...	20	NOPR ORAS	KRH-PP 1	KRH-FAC	
3101563021	M3	8301438898		06.10.2019	17.10.2019	RM1	KRH-HILIR-KR...		ROUTINE KRH1 - STRAIN...		NOPR ORAS	KRH-PP 1	KRH-MECS	
3101563020	M3	8301438897		06.10.2019	17.10.2019	RM1	KRH-HILIR-KR...		ROUTINE KRH1 - STRAIN...		NOPR ORAS	KRH-PP 1	KRH-MECS	
3101563072	M3	8301438900		06.10.2019	09.10.2019	RM2	KRH-HILIR-KR...		ROUTINE KRH1 HVAC		NOPR ORAS	KRH-PP 1	KRH-MECR	
3101563026	M3	8301438899		06.10.2019	17.10.2019	RM1	KRH-HULU-0K...	0K51BRV10/00	ROUTINE KRH1 - DAILY F...		NOPR ORAS	KRH-CLS 5	KRH-MECS	
3101563019	M3	8301438896		06.10.2019	17.10.2019	RM1	KRH-HILIR-KR...	KRH1EGB20BB00...	ROUTINE KRH1 OT DIRT...		NOPR ORAS	KRH-PP 1	KRH-MECS	
4000091766	M4		1000...	06.10.2019	07.10.2019	ROP	KRH-HILIR-KR...		KRH1 DAILY CHECKSHEE...	-	NOPR	KRH-PP 1	KRH-OPS	
4000091822	M4		1000...	07.10.2019	07.10.2019	ROP	KRH-HILIR-KR...		KRH1 DAILY CHECKSHEE...	-	NOPR	KRH-PP 1	KRH-OPS	

Figure 2 : Notification list of routine maintenance daily activities

This time-based maintenance system in impelented from 2009. Control system for GPP Unit 4 is monitored in control room using Distributed Control System (DCS) so at the moment PGE had two control rooms, i.e : PLC room in Kamojang Head Office for

monitoring steam facilities and DCS room for monitoring equipment in GPP. For effectiveness purposes, This two control rooms by 2014 is centralized become one control room in GPP and all of the equipment both steam gathering facilities and power plant equipment is controlled using DCS.

By 2015, Unit 5 was commercially operated by PGE which the steam are supplied from 3.3 km-lenght PL-406. Control system for Unit 1,2,3, 4 and 5 are now centralized in Control Room KMJ Unit 5. At the moment, PGE start to implemeneted condition monitoring for its equipments by launcing Reliability Centered Maintenance (RCM) based Maintenance Program as an advance integrated smart machine to ensure that the system continue to do as the requirement in their present operating context. Over 7000 equipments are assessed based on their criticality and maintenance program are made using failure mode and effect analysis for those critical equpment. For those which is less critical is maintain using normative maintenance method. Thus the reliability of equipments is garanted for energizing electricity. Not only the equipments, we also register all of the sparepartsof the equipment and put some unique material and stardard code for each spare part so that went maintenance departement need those spare part to be replaced, then this smart machine will generate noticifation to Supply Chain Management (SCM) Departement to check the availabiilty of the part and deliver the spare part to maintenance group. Figure 3 shows structural list of equipment and breakdown of spare part.

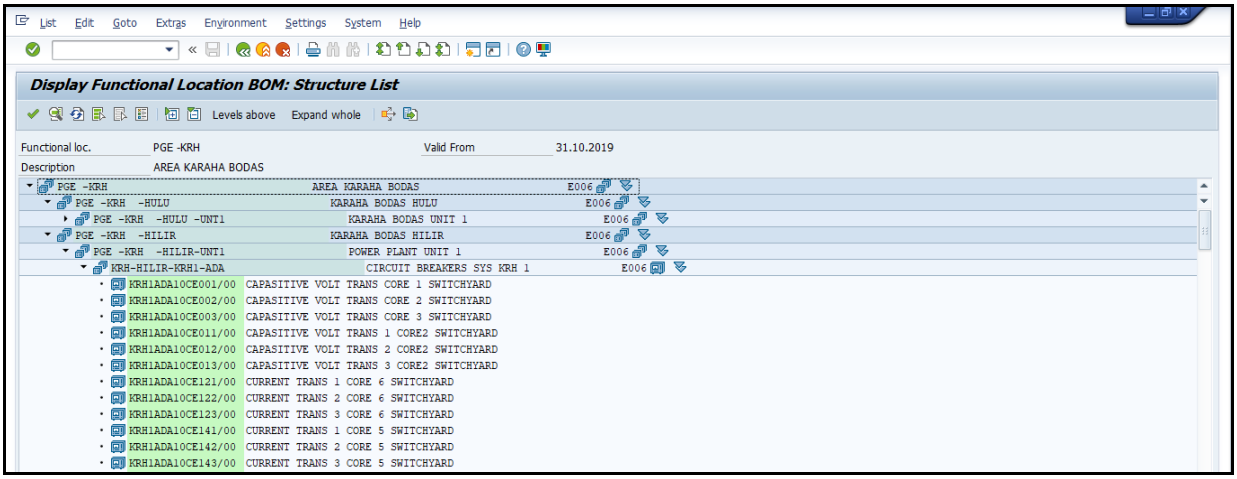
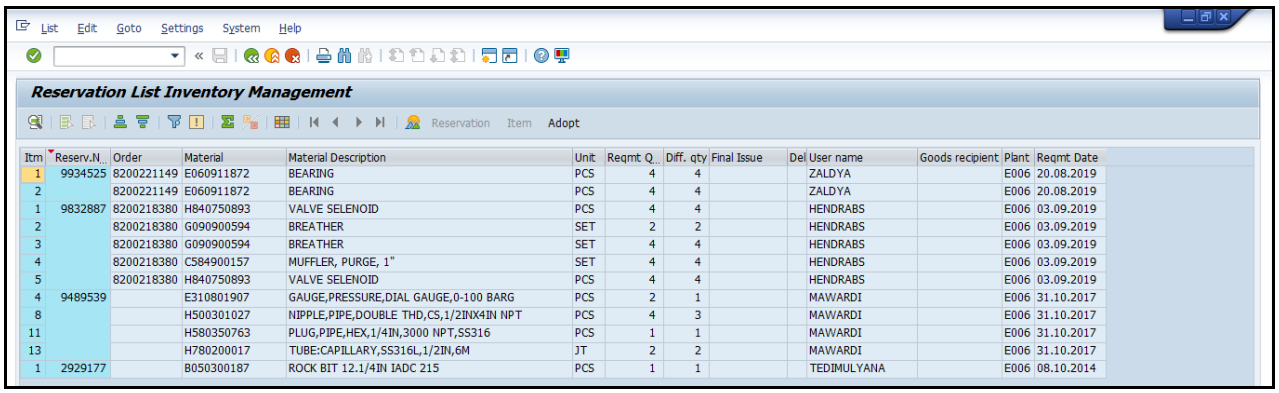


Figure 3 : Structural list of equipment and breakdown of spare part

This smart machine also helps us in maintain safety stock of each consumable spare part and give alert if the spart part reach minimum level of the stock and buy spare part to full fill the stock. Figure 4 shows list of reservation for material as part of inventory management. Using this data, SCM Department will make a plan to purchase the material or spare part needed.



Itm	Reserv.N	Order	Material	Material Description	Unit	Reqmt Q	Diff. qty	Final Issue	Del	User name	Goods recipient	Plant	Reqmt Date
1	9934525	8200221149	E060911872	BEARING	PCS	4	4			ZALDYA		E006	20.08.2019
2		8200221149	E060911872	BEARING	PCS	4	4			ZALDYA		E006	20.08.2019
1	9832887	8200218380	H840750893	VALVE SELENOID	PCS	4	4			HENDRABS		E006	03.09.2019
2		8200218380	G090900594	BREATHER	SET	2	2			HENDRABS		E006	03.09.2019
3		8200218380	G090900594	BREATHER	SET	4	4			HENDRABS		E006	03.09.2019
4		8200218380	C584900157	MUFFLER, PURGE, 1"	SET	4	4			HENDRABS		E006	03.09.2019
5		8200218380	H840750893	VALVE SELENOID	PCS	4	4			HENDRABS		E006	03.09.2019
4	9489539		E310801907	GAUGE,PRESSURE,DIAL GAUGE,0-100 BARG	PCS	2	1			MAWARDI		E006	31.10.2017
8			H500301027	NIPPLE,PIPE,DOUBLE THD,CS,1/2INX4IN NPT	PCS	4	3			MAWARDI		E006	31.10.2017
11			H580350763	PLUG,PIPE,HEX,1/4IN,3000 NPT,SS316	PCS	1	1			MAWARDI		E006	31.10.2017
13			H780200017	TUBE:CAPILLARY,SS316L,1/2IN,6M	JT	2	2			MAWARDI		E006	31.10.2017
1	2929177		B050300187	ROCK BIT 12.1/4IN IADC 215	PCS	1	1			TEDIMULYANA		E006	08.10.2014

Figure 4 : Reservation List Inventory Management

Using data from smart machine, we can also analize which spareparta are categorized as fast moving spare parts and slow moving spare parts. In these smart machine, the price for those spare parts also are well maintaned so that once material is issued to maintenance department, then such an amount of money will be charged to maintenance departement. At these point, we are not only be able to maintain the GPP in order to maintain availability and reliability, we can also analize how much we spent to maintenance equipments during operation of GPP and steam gathering system. This is how the integrated smart machine has a contribution to the availability or the reliability of the system.

Three years after that, PGE introduced Android based Seamless Asset Management System (SAMS) are applied for maintenance program. This program replace previous paper-based check sheet with digital-based check sheet in order to reduce time and manpower. These improvement always implement in Kamojang as a mature field and are followed by other field such as Ulubelu Field, Lahendong Field, Sibayak Field and Karaha Field.

5. AVAILABILITY AND RELIABILITY

Operation and maintenance improvement in PGE is applied in order to ensure equipment reliability and power plant availability. For the past 3 years, PGE has proved their capabilities in operational and maintenance. Below table present availability and reliability GPP for 2016 – 2018, showing that average availability and reliability rate are more than 90% respectively.

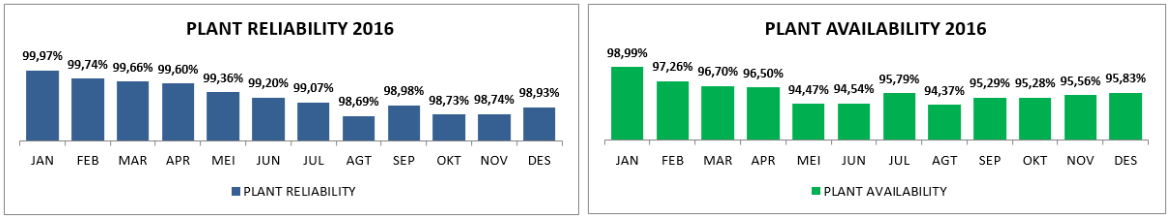


Table 1 : PGE Plant Reliability & Availability in 2016

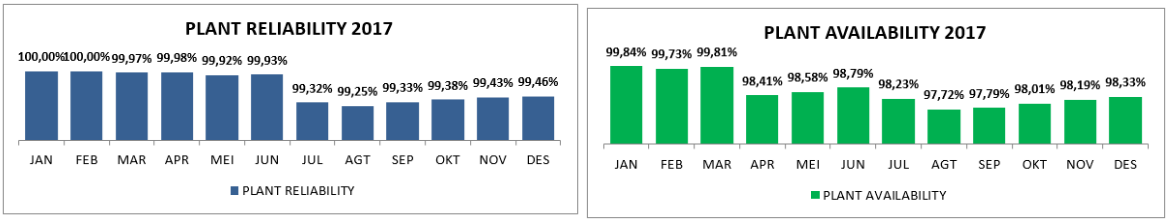


Table 2 : PGE Plant Reliability & Availability in 2017

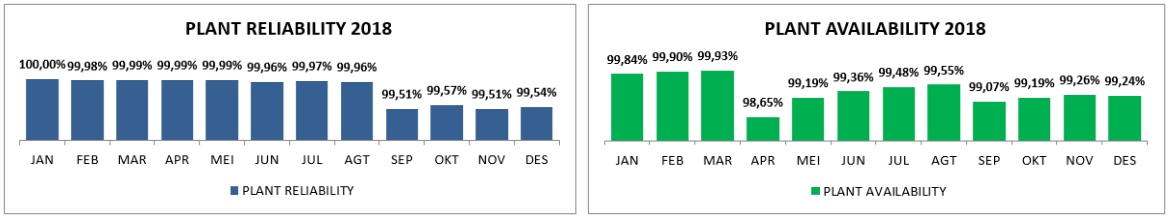


Table 3 : PGE Plant Reliability & Availability in 2018

6. CONCLUSION

In developing geothermal energy, PGE has experienced several method of monitoring way. Initially on 1983, PGE use manual analog monitoring system. It took around 10 years for PGE to switch from analog to digital monitoring system. While digitalization goes even further, 14 years after that, PGE start to optimize the use of integrated smart machine to help them in maintain the power plant and gives contribution to the availability or the reliability of the system. Finally combination between Reliability Centered Maintenance and Risk Based Inspection is considered to be the best maintenance and operation practise in order to ensure the plant available in generating electricity

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