



PT Pertamina Gas – Operation East Java Area

Strategi Pengendalian Black Powder di Jalur Pipa Transmisi Gas: Studi Kasus dan Rekomendasi



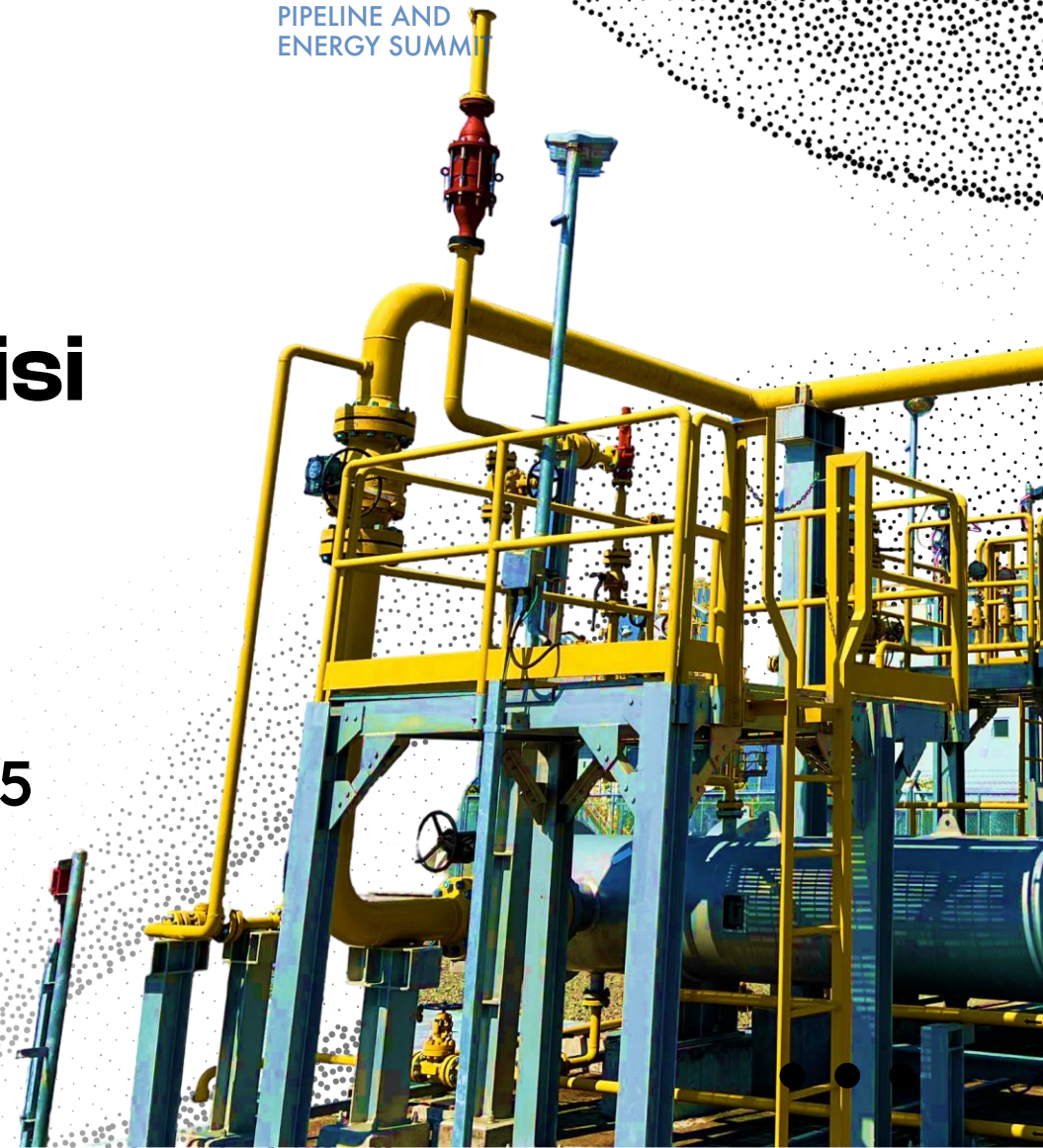
Dimas Satrya K. B



17 Juni 2025



Westin Hotel, Jakarta



PT PERTAMINA GAS OEJA

Company Profile



Operation East Java Area

Gas Transmission
Pipelines

- Segments: 10
- Total Length: 775 km
- Size: 10-28 inch

PRESENTED AT:

pipes 2025

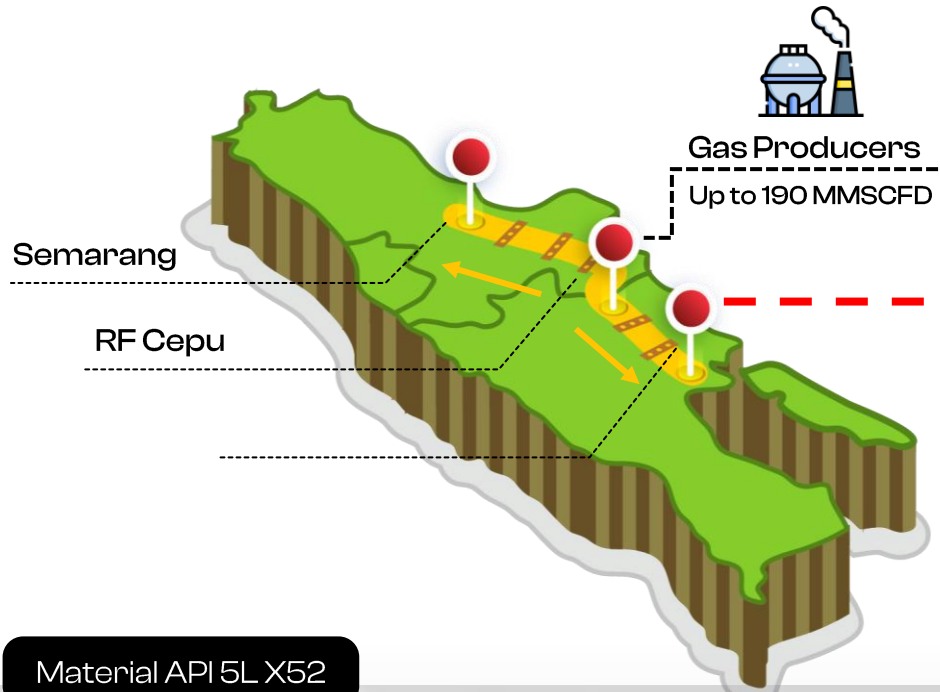
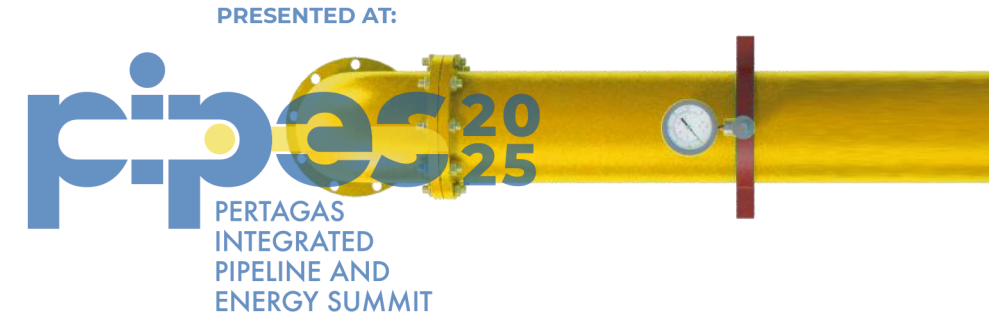
PERTAGAS
INTEGRATED
PIPELINE AND
ENERGY SUMMIT

Central & East Java



Kondisi Operasional

Ruas 28" Gresik - Semarang



Material API 5L X52

28 inch

Diameter

125 km

Panjang Pipa

Equipment:

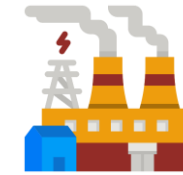
- Sistem Metering
- IT Scada
- Filtration System (strainer meter)
- Safety Device



Consumer:



Fertilizer Plant
> 8 million ton p.a



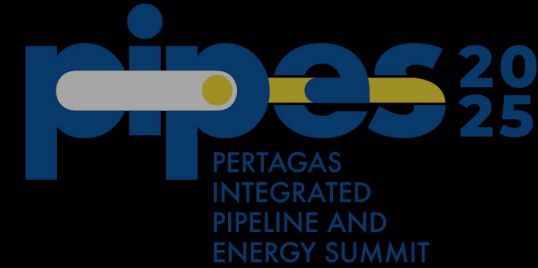
Power Plant
>1300 MW



Unsur Kimia Gas	% mole
Methane	89.5633
Ethane	3.1289
Propane	1.0422
Butane	0.4050
Nitrogen	0.3744
CO ₂	5.4634
H ₂ S	0.0002
H ₂ O	0.0013
lainnya	0.0213

Average April-Mei 2025

PRESENTED AT:



Apa itu **BLACK POWDER?**

• • • • •

BLACK POWDER

Granular contaminant in natural gas pipeline



Black Powder

Kontaminan halus dan korosif dalam pipa gas alam, terdiri dari oksida, sulfida besi, dan pengotor lainnya yang dapat menyebabkan gangguan aliran gas dan kerusakan peralatan instalasi migas

Black powder yang ditemukan pada 32" Barrel of Pig Receiver pada 28" Transmission Gas Pipelines Gresik – Semarang pada kegiatan *pigging*

Potensi Sumber Black Powder

Dampak

- 1 Mill scale dari proses manufaktur pipa
 - 2 Reaksi korosi lingkungan selama penyimpanan pipa
 - 3 Proses *pre-commissioning & commissioning* (dewatering process, dsb)
 - 4 Senyawa korosif dalam gas (e.g. H_2O , H_2S , CO_2) dan kondisi operasi yang menyebabkan korosi internal
 - 5 Carryover dari fasilitas produksi gas di sisi hulu
- Penurunan *Flow Rate* Penyaluran Gas
 - Komplain Konsumen Gas
 - Erosi & Integrity Pipa
 - Tingginya Biaya O&M

BLACK POWDER

Granular contaminant in natural gas pipeline



Proses Pembentukan



Reaksi Korosi

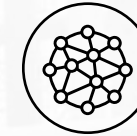
Terjadi di ruas pipa penyalur

Dipicu oleh adanya *moisture*, CO₂, H₂S dan komponen korosif lainnya



Oksidasi & Reaksi Kimia

Terjadi reaksi kimia antara pipa dengan komponen korosif (zat asam)

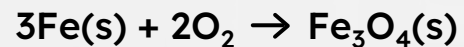


Akumulasi Partikel

Membentuk deposit black powder dalam pipa

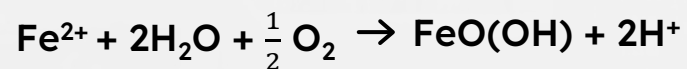
Magnetite

Oxygen-limited oxidation



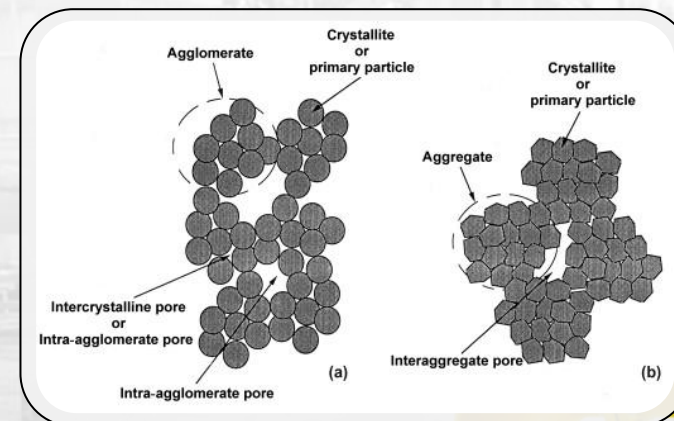
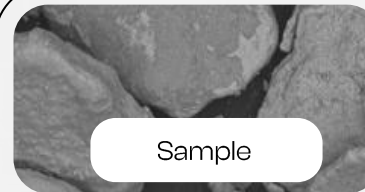
Goethite

Partial oxidation with moisture



Iron Carbonate

Absorption of CO₂ in water



Case Study :

Black powder di berbagai belahan dunia

PRESENTED AT:



Uni Emirat Arab

Terjadi di Abu Dhabi
National Oil&Gas
Company (ADNOC) dan
GASCO Pipeline Network
(*Khan and et al., 2015*)



Arab Saudi

Terjadi di Saudi Aramco
Pipeline Network
(*Trabulsi, 2017*)



Amerika Serikat

Terjadi di salah satu plant
pada natural gas
processing plant's : Waste
Heat Recovery Unit
(WHRU) di Carolina, USA
(*Powell and et al., 2012*)



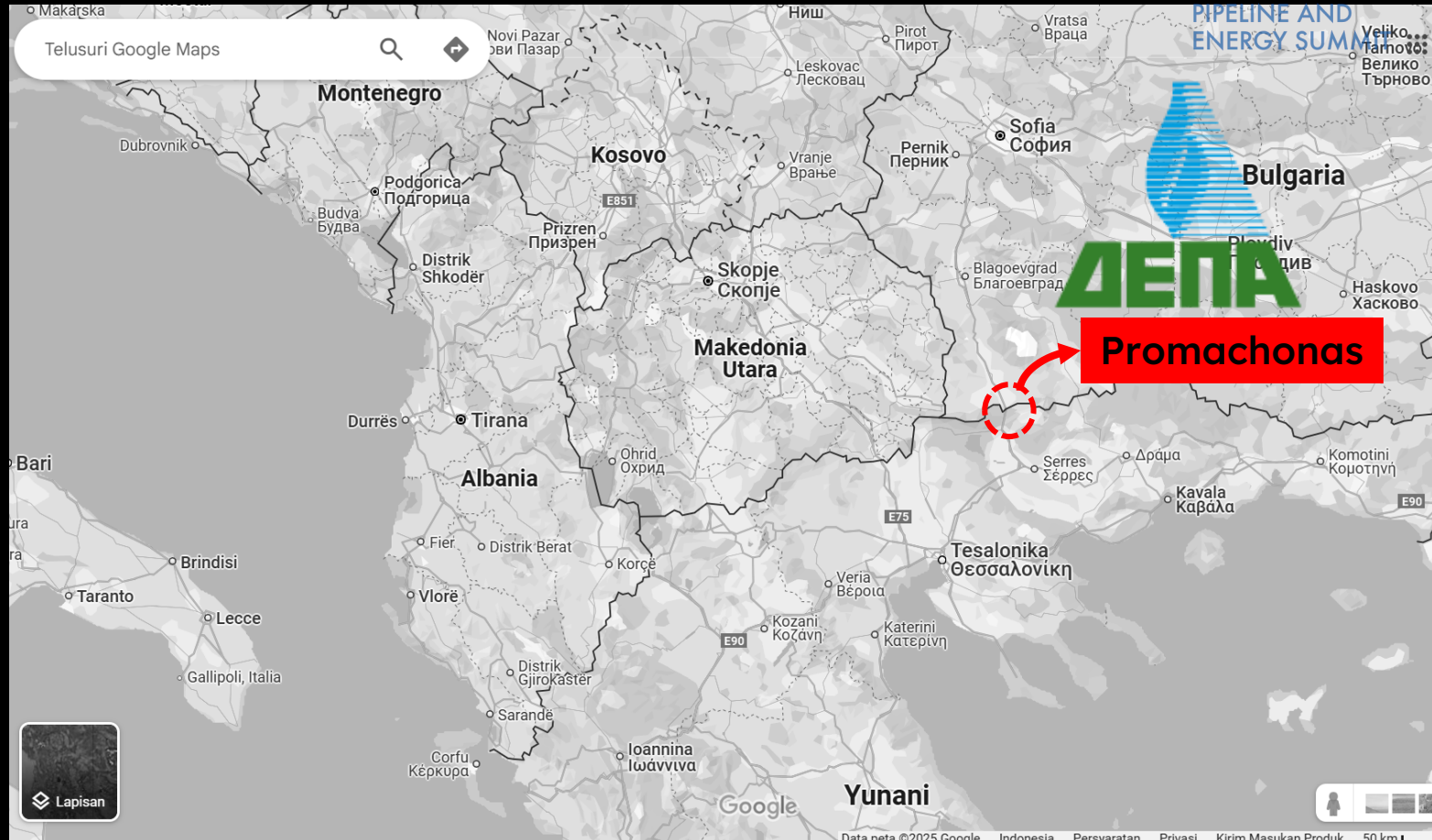
Yunani

Terjadi di ruas pipa
transmisi gas milik DEPA
pada Bulgarian/Greek
border ke border metering
station (BMS) di
Sidirkastro
(*Tsochatzidis and Maroulis., 2007*)

CASE STUDY :

DEPA ΔΕΠΑ (Dimósia Epicheirisi Aerou)

In 36" x 12 km Gas Pipelines - Greece's state-founded natural gas company



Black powder also **threatened** to cloud customers' impressions of natural gas as the "clean fossil fuel"

What's on DEPA?

"Greek Public Gas Corp SA's (DEPA's) experience in fighting black powder in its system"

1

Jumlah black powder yang tertangkap dari kegiatan pigging : >11,620 kg

2

Treatment fokus pada *physical removal*, tanpa ada *chemical treatment*

3

Dampak yang dialami :

- *Clogged & collapsed filters*
- *Deposits on gas measurement devices*
- Penurunan efisiensi aliran
- *Penurunan Fungsional dan realibilitas peralatan*

4

Komponen major : Magnetite (Fe_3O_4) and Quartz (SiO_2)

Komponen minor : Goethite ($\text{FeO}(\text{OH})$), Bementite, Manganese Oxide, dll

5

Pengendalian Black Powder :

- Penggantian filter berkala
- *Series of Pigging* (inc. BiDi, Magnetic pig, Brush Pig)
- Instal *cyclone filter*
- Analisa Sample di Laboratorium



Strategi Utama DEPA : **Filtration**

"The particles are able to shear easily at submicron sizes and pass through gas separation devices and filter capable of trapping particles as small as submicron"

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Vertical Catridge Filter with Vessels

- Lokasi : Border Metering Entrance Station **Upstream Pipeline**
- Fungsi : Menghilangkan condensate, air, *scale*, dan material asing lainnya
- Material filter : fiber glass dengan phenolic resin dan silicon
- Batas dP Filter : >2 bar (29 psi)
- Efisiensi Separasi : 100% untuk partikel >3mikron, dan 99% partikel 0.5 – 3 mikron
- Frekuensi Penggantian Filter : ~3x / minggu

Cyclone (Centrifugal) Separators

- Lokasi : **Downstream pipeline**
- Fungsi : remove debris, separasi compressor oil dan air dari aliran gas
- Batas operasi : ~1,000 kg
- Efisiensi Separasi : 99% partikel > 5 mikron

Ref: Tsochatzidis, N. A., & Maroulis, K. E. (2007). Methods help remove black powder from gas pipelines. *Oil & Gas Journal*, 105(1), 54-58.

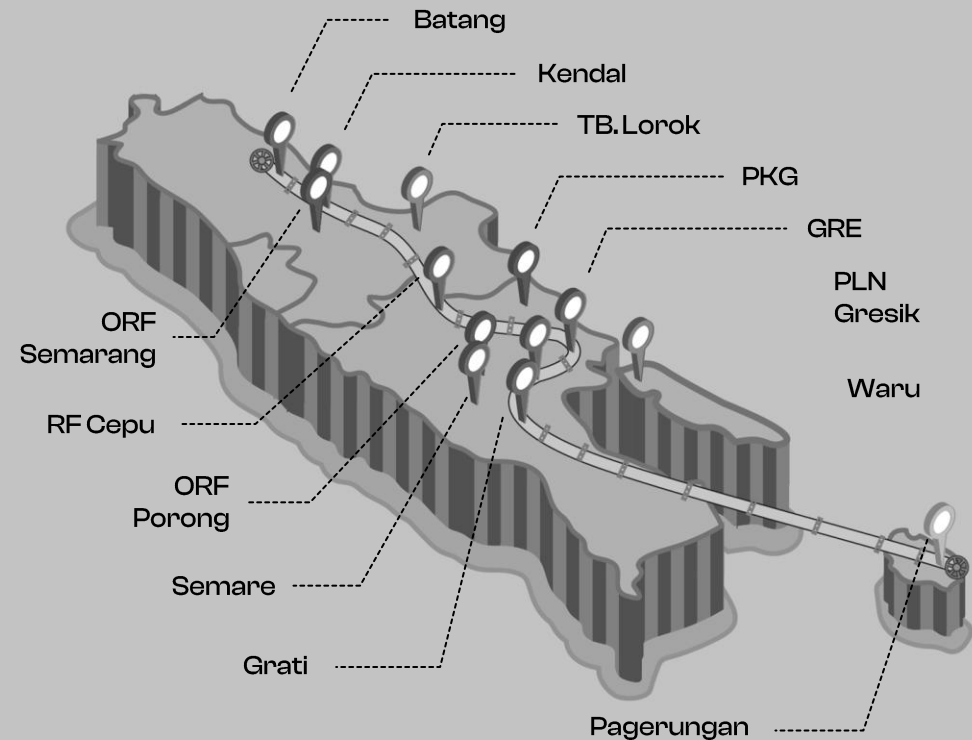
CASE STUDY:

28" Gresik – Semarang Pipeline

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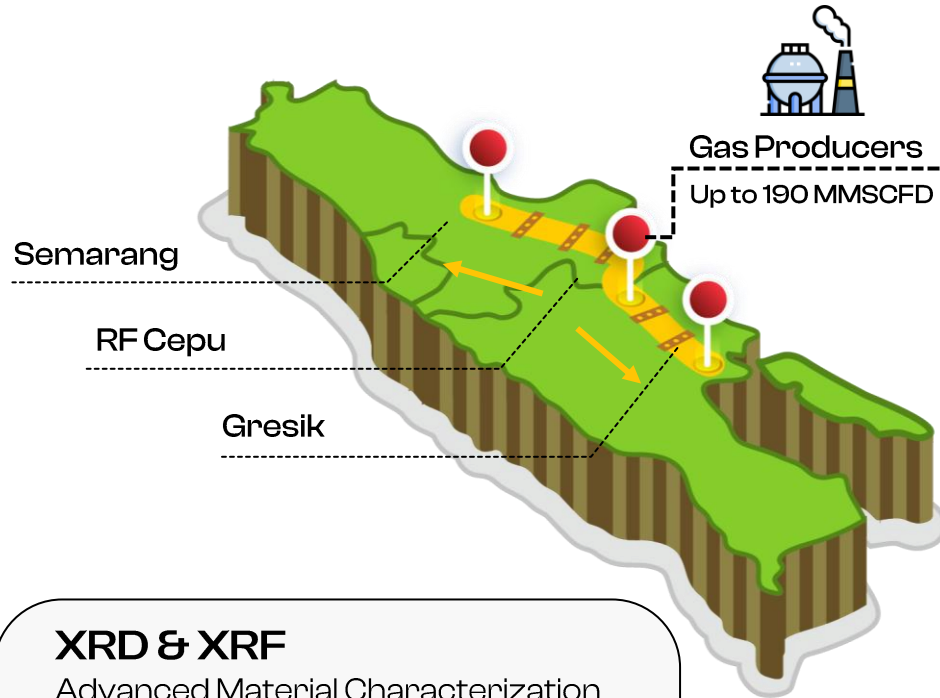
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Central & East Java



Isu Operasional Utama

Black Powder



XRD & XRF

Advanced Material Characterization



Magnetite



Goethite

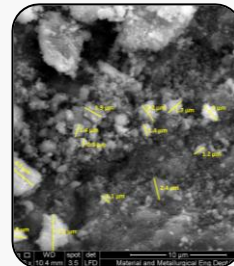


Iron Carbonate

Shieving

<74 μ

Fraksi terbesar ($\pm$ 40%)
pada ukuran



Kenaikan dP pada gas filter
dan potensi clogging



Tingginya frekuensi
penggantian filter



Komplain Konsumen Gas



Erosi & Integrity Pipa



Tingginya Biaya O&M

PRESENTED AT:



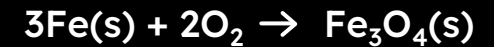
Formation

Black Powder Components



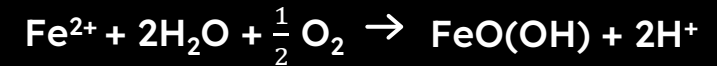
Magnetite

Oxygen-limited oxidation



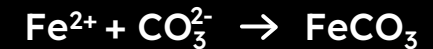
Goethite

Partial oxidation with moisture



Iron Carbonate

Absorption of CO_2 in water



$\pm$ 10,000 kg

Massa

Jumlah
Tertangkap

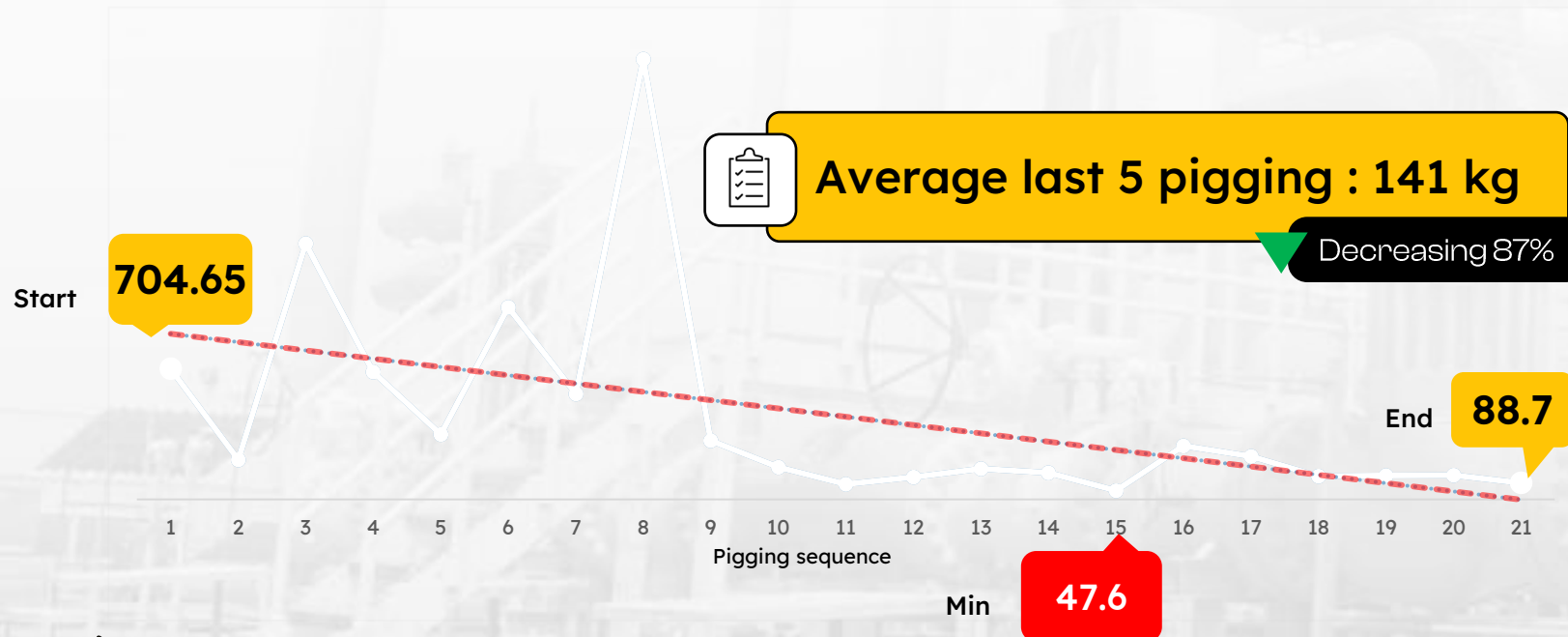
Juli 2023 – Sekarang

Metode Pembersihan

Physical Removal

21 Stages

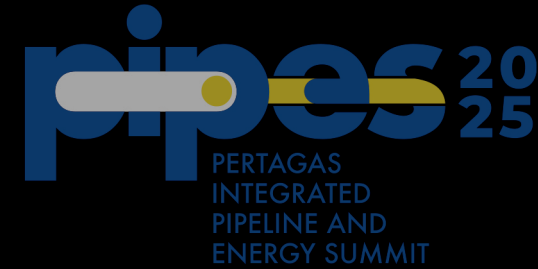
Sequence pigging



➤ Efektif dalam menurunkan akumulasi jumlah black powder



PRESENTED AT:



Eksistensi Black powder terhadap INTEGRITAS PIPA

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THICKNESS MEASUREMENT

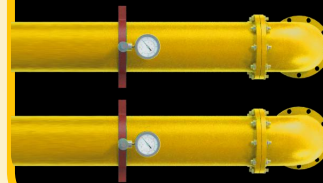
28" Gresik – Semarang Pipeline



TML Testing

- Thickness Measurement Location
Riser pipe on LBCV, Straight Pipe, and Elbow
- Periodically – 6 Month

Conclusion



- No significant Thickness reduction detected (avg < 3%)
- Further testing method required!
- Not conclusively attribute thinning erosion

Thickness Reduction Points

Initial thickness: **11.91 mm**

➤ Rank #1

Thickness Reduction
3.21% ~ 0.38 mm

Final thickness
11.53 mm

➤ Rank #2

Thickness Reduction
2.20% ~ 0.26 mm

Final thickness
11.65 mm

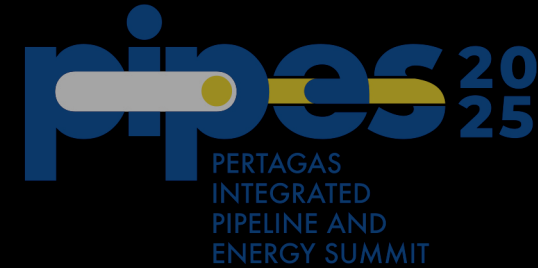
➤ Rank #3

Thickness Reduction
1.36% ~ 0.16 mm

Final thickness
11.75 mm



PRESENTED AT:



Metode Investigasi Akar Penyebab: **SUMBER BLACK POWDER**

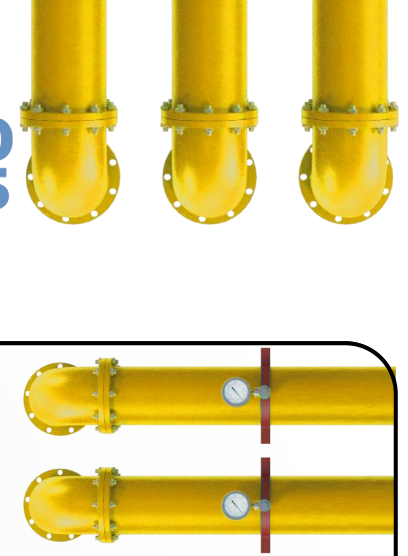
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TESTING METHOD [1]

Identifikasi karakterisasi black powder

PRESENTED AT:



XRD (X-Ray Diffractometer)

Advanced Material Characterization

Senyawa Dominan

- **Magnetite**
Oxygen-limited oxidation
$$3\text{Fe(s)} + 2\text{O}_2 \rightarrow \text{Fe}_3\text{O}_4\text{(s)}$$
- **Goethite**
Partial oxidation with moisture
$$\text{Fe}^{2+} + 2\text{H}_2\text{O} + \frac{1}{2}\text{O}_2 \rightarrow \text{FeO(OH)} + 2\text{H}^+$$
- **Iron Carbonate**
Absorption of CO_2 in water
$$\text{Fe}^{2+} + \text{CO}_3^{2-} \rightarrow \text{FeCO}_3$$

Elemen Lainnya

- **Calcium Sulfat**
$$\text{Ca}^{2+} + \text{SO}_4^{2-} \rightarrow \text{CaSO}_4$$
- **Iron Sulfide**
$$\text{H}_2\text{O (condensed water)} + \text{H}_2\text{S} \rightarrow \text{H}_3\text{O}^+ + \text{H}^-$$

$$\text{HS}^- + \text{Fe (steel pipe)} \rightarrow \text{FeS} + \text{H}_2$$
- **Senyawa lainnya yang mengandung Al, Mg, Na, K, Si, Ba**

TESTING METHOD

Potensi terbentuk dari mill scale



Metode verifikasi atas pembuktian asal black powder dari mill scale

Mill scale biasanya terbentuk pada proses oksidasi besi pada temperature tinggi, terjadi diatas 570 °C

Identifikasi keberadaan elemen senyawa FeO (wüstite) tidak ditemukan
Proses mill scale tidak berperan dalam pembentukan black powder

➤ Wuestite



MillScale.org
CONSULTING AND SALES

TESTING METHOD

Potensi Berasal dari sumber lain

Metode verifikasi atas pembuktian asal black powder dari sumber lain



Identifikasi keberadaan elemen senyawa calcium sulphate (CaSO_4), senyawa sulfur dan elemen mineral lainnya yang tidak biasa ditemukan pada mills manufaktur pipa

Potensi black powder berasal dari sumber lain

► Calcium Sulfate



► Iron Sulfide



TESTING METHOD

Potensi dari kondisi parameter operasional



Metode verifikasi atas pembuktian black powder dari kondisi operasi pipa
Gresik - Semarang

Identifikasi keberadaan elemen senyawa Fe_3O_4 , $\text{FeO}(\text{OH})$, dan FeCO_3 yang terdeposit pada pipa

Tidak ditemukan kandungan air yang signifikan pada aliran gas

Nilai komposisi gas masih berada pada ambang batas mengacu pada access arrangement (AA)

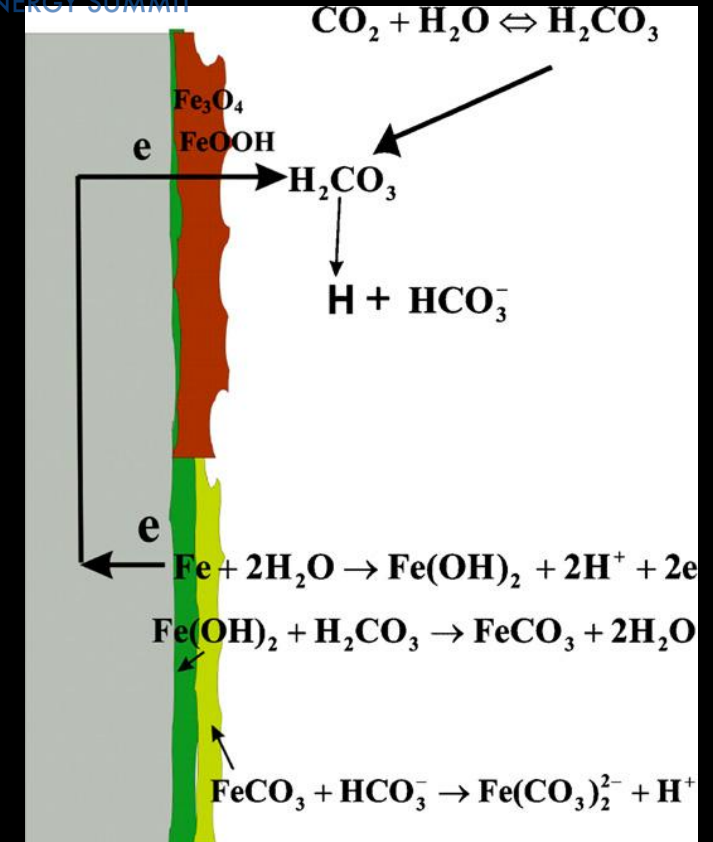
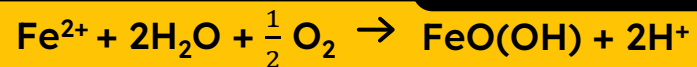
➤ Iron Carbonate



➤ Magnetite



➤ Goethite





TESTING METHOD

Determine if Black Powder Comes From Internal Corrosion



Atmospheric Testing

Degradation of metals cause by exposure air

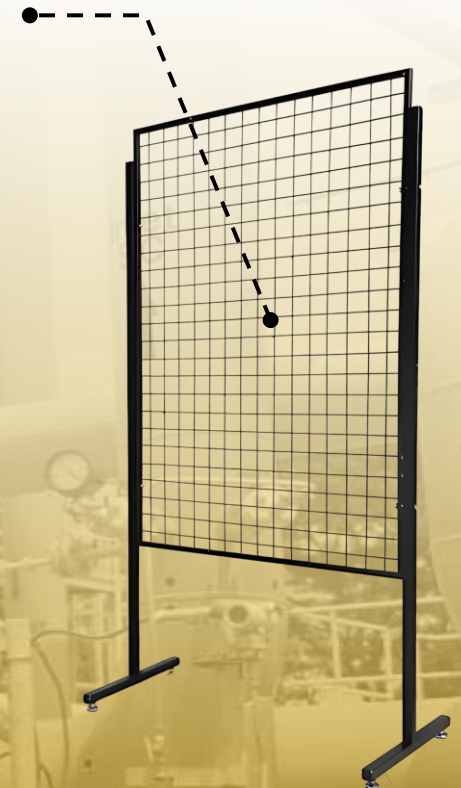
Key Factors

-  **Pollutants**
(SO₂, H₂S, NO_x, chlorides)
-  **Temperature**
-  **Humidity**
-  **Weather factors**

Step

- 1 Identify corrosion product composition**
- 2 Compares results with black powder in pipelines**
- 3 Determines if both have identical composition**

Sample: Uses the same material affected by black powder



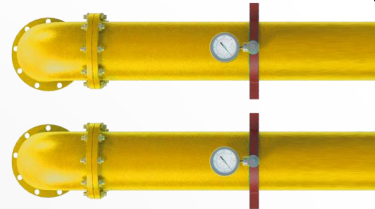
TESTING METHOD

Determine if Black Powder Comes From Internal Corrosion



HPHT Autoclaves

With Rotating Cage



Verifies if black powder originates from internal corrosion

Identifies corrosion products under controlled conditions

Simulates corrosive environments under

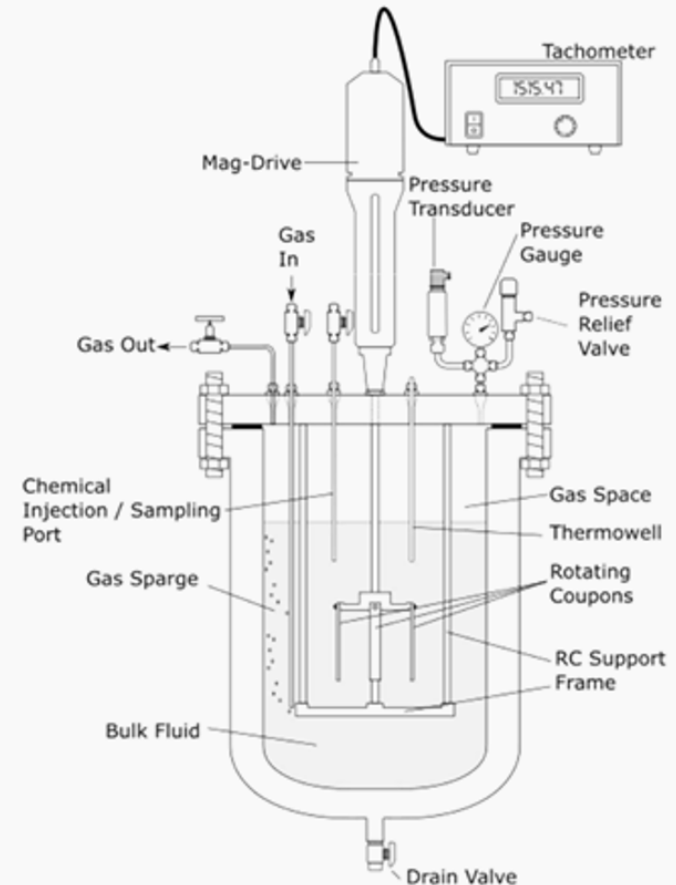
High temperature and pressure

Evaluates the influence on corrosion

➤ CO₂ ➤ H₂O
 ➤ H₂S

Provide insights the effect of

➤ Gas flow rate ➤ Pressure on metal degradation

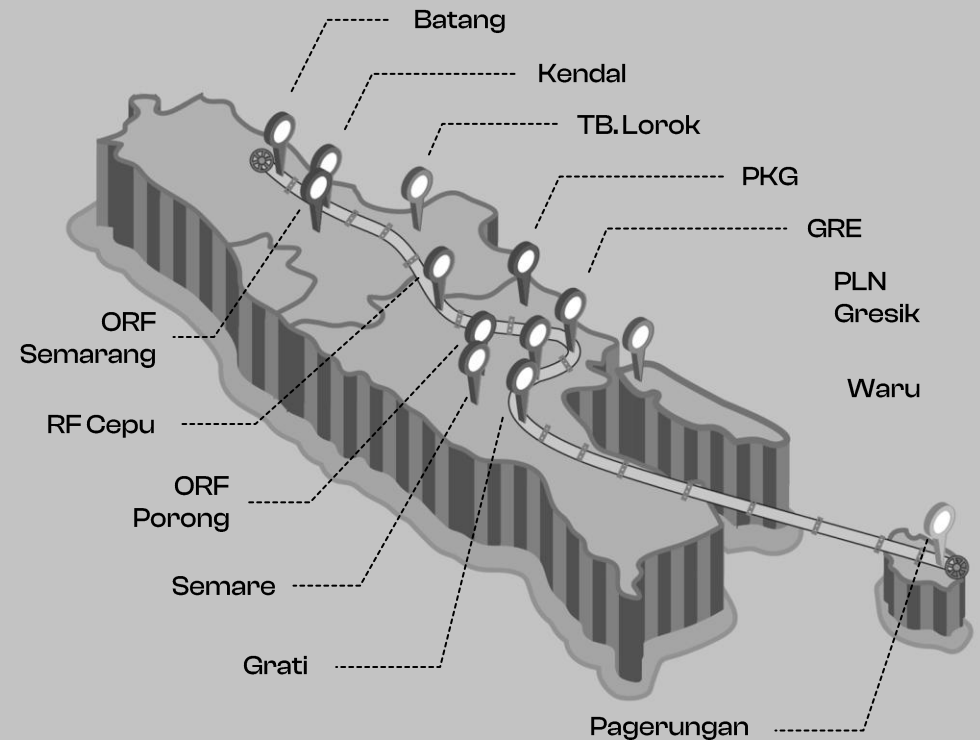


Strategi dan Rekomendasi

PT Pertamina Gas – Operation East Java Area



Central & East Java



COMBINATION METHOD

Progressive Pigging

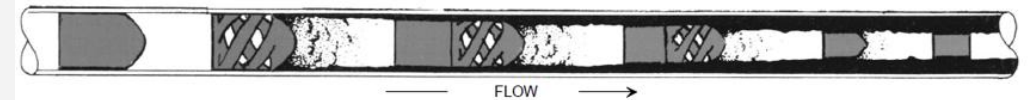
Progressive Pigging



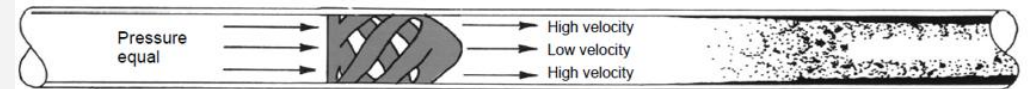
A staged cleaning process using foam pigs, cup pigs, and BiDi pigs with accessories.



Effectively reduces black powder Accumulation and minimizes pigging failure risks.



This diagram shows schematically how the progressive pigging technique works by shaving off successive layers of encrustation gradually, so avoiding a "plugged" line.



This illustrates the forces at work enabling the POLLY PIG to clean efficiently and keep debris ahead in a state of suspension.

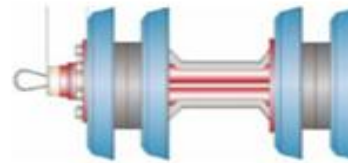
Pig Type Selection

1



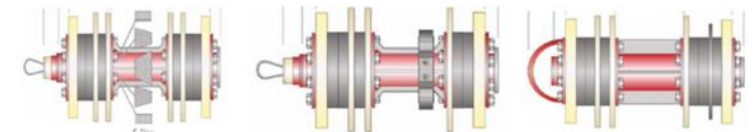
Foam Pig

Initial stage, low risk of getting stuck



Cup Pig

More effective cleaning, wear buttons prevent failure

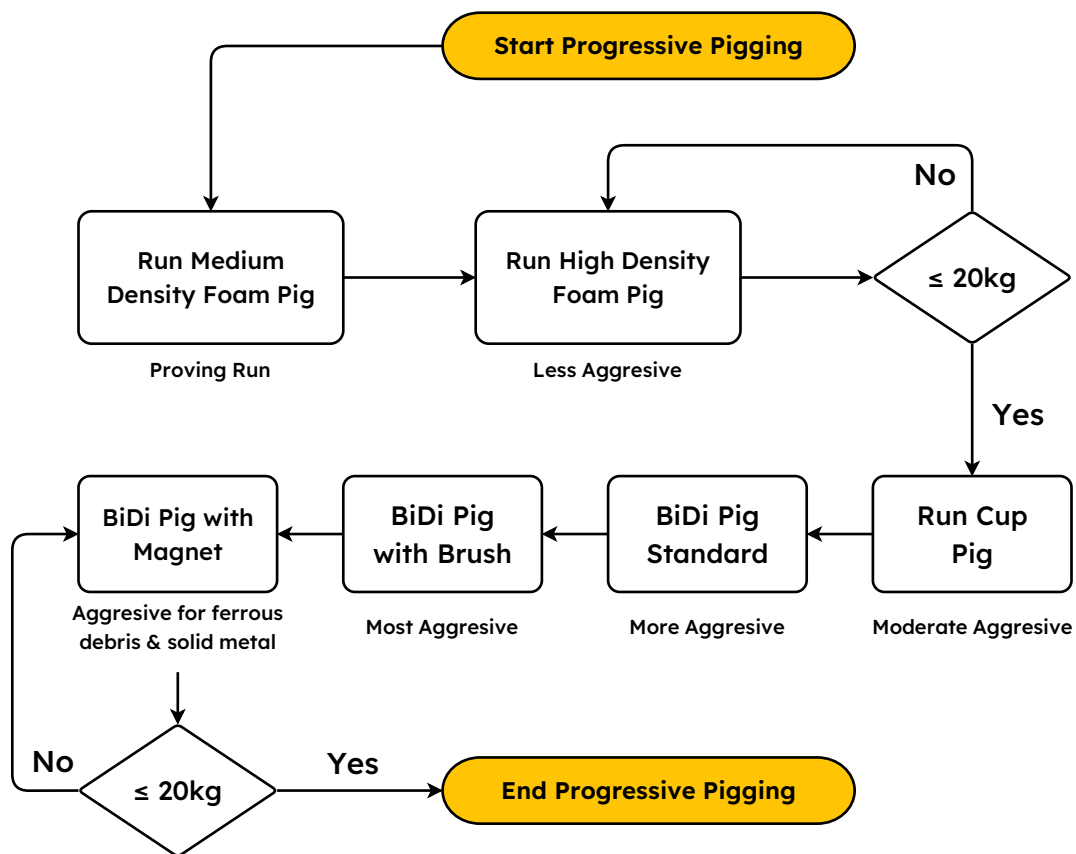


BiDi Pig

Final stage, equipped with brushes & magnets for deep cleaning

COMBINATION METHOD

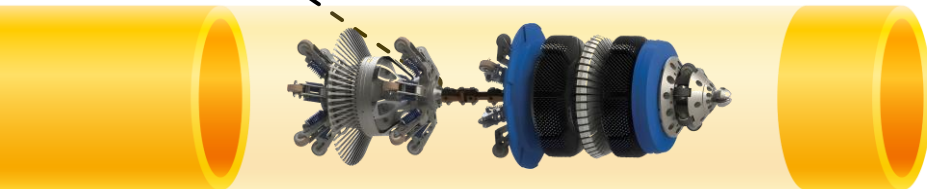
Progressive Pigging



In-Line-Inspection & Gas Monitoring

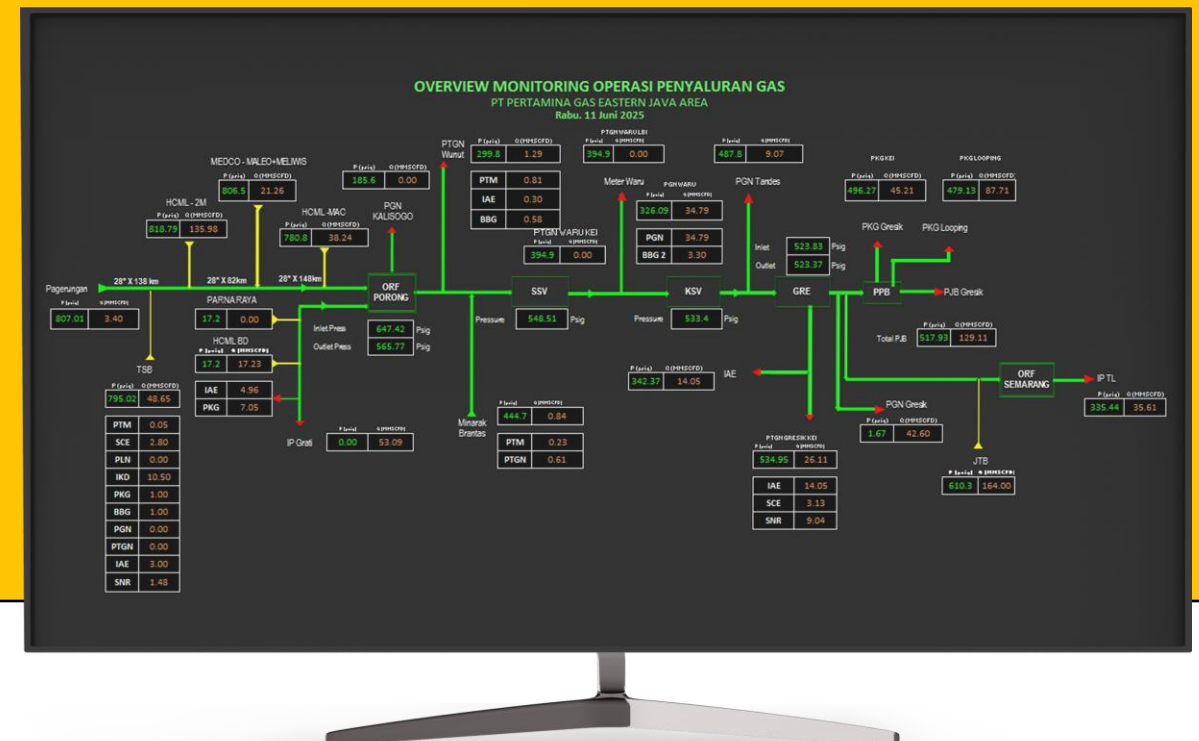
2 MFL In-Line Inspection (ILI)

- Uses Magnetic Flux Leakage to detect pipeline defects and assess corrosion



Monitoring of Operation Parameter

pressure, temperature, flow rate, gas composition



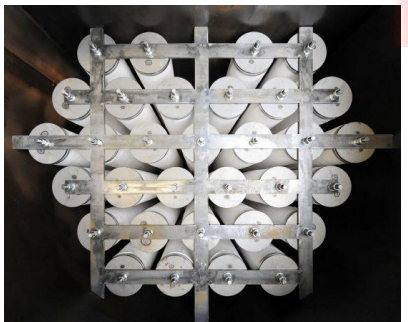
COMBINATION METHOD

Methods for Controlling Black Powder

4

Gas Filters

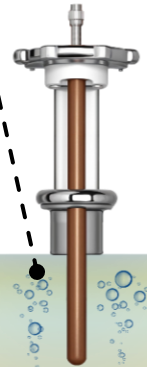
Cyclone, dry gas, or magnetic filters remove solid contaminants for cleaner gas flow



5

Corrosion Inhibitors

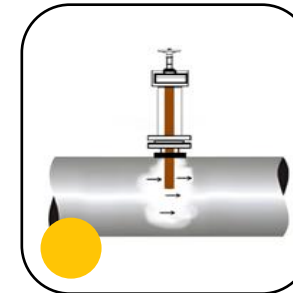
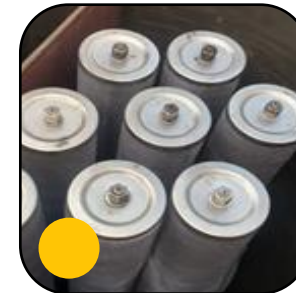
Chemicals form a protective layer to prevent internal corrosion

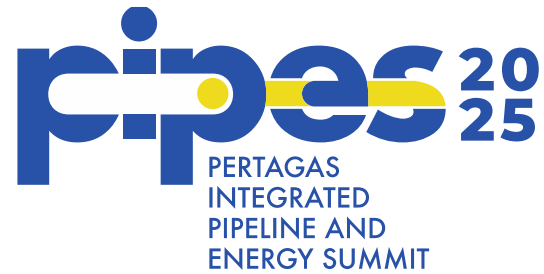


6

Pipe Reinforcement

Strengthens pipelines with sleeves or clamps to restore integrity and prevent leaks





TERIMA KASIH

"Kemajuan tidak diukur dari seberapa cepat kita berlari, tapi dari arah yang benar kita tuju"

Abdurrahman Wahid (Gus Dur)